RTO-MP-21
AC/323(HFM)TP/8

RTO-MP-21

NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

RTO MEETING PROCEEDINGS 21

Aeromedical Aspects of Aircrew Training

(les Aspects aéromédicaux de la formation des équipages)

Papers presented at the Human Factors and Medicine Panel (HFM) Workshop held in San Diego, USA, 14-18 October 1998.

Published June 1999

Distribution and Availability on Back Cover

RTO-MP-21
AC/323(HFM)TP/8

NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

RTO MEETING PROCEEDINGS 21

Aeromedical Aspects of Aircrew Training

(les Aspects aéromédicaux de la formation des équipages)

Papers presented at the Human Factors and Medicine Panel (HFM) Workshop held in San Diego, USA, 14-18 October 1998.

The Research and Technology Organization (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote cooperative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective coordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also coordinates RTO's cooperation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of initial cooperation.

The total spectrum of R&T activities is covered by 7 Panels, dealing with:

- SAS Studies, Analysis and Simulation
- SCI Systems Concepts and Integration
- SET Sensors and Electronics Technology
- IST Information Systems Technology
- AVT Applied Vehicle Technology
- HFM Human Factors and Medicine
- NSPG NATO Simulation Policy Group (Modelling and Simulation)

These Panels are made up of national representatives as well as generally recognised 'world class' scientists. The Panels also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier cooperation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

The content of this publication has been reproduced
directly from material supplied by RTO or the authors.

Printed on recycled paper

Published June 1999

ISBN 92-837-1016-9

Printed by Canada Communication Group Inc.
(A St. Joseph Corporation Company)
45 Sacré-Cœur Blvd., Hull (Québec), Canada K1A 0S7

Aeromedical Aspects of Aircrew Training

(RTO MP-21)

Executive Summary

The Human Factors and Medical Panel of NATO's Research and Technology Organization (RTO) sponsored a Workshop to bring together Aeromedical Trainers to discuss current Aeromedical Training Programmes and to present some new approaches to providing training. In addition, time was provided for attendees to discuss various approaches to Aeromedical Training and to review STANAG 3114 "Aeromedical Training of Flight Personnel". Presentations included: categories of training, subject taught, frequency of training, duration of courses, period of validity and altitude chamber profiles utilized.

The objectives of the Workshop were met. Most NATO countries were present and provided overviews of their programmes, as did representatives from Poland and the Czech Republic. Presentations were also made on new approaches to Aeromedical training including: Simulator Based Physiology Training (SYMPHYS). Simulator Based Disorientation Training and In-Flight Disorientation Training.

Attendees were also able to agree on a number of recommended changes to STANAG 3114 including, but not limited to: removal of the split between Rotary and Fixed-wing aircraft training requirements, addition of the requirement for instruction on aeromedical aspects of new Life Support Equipment and addition of the requirement for a practical Spatial Disorientation experience during refresher training.

Attendees also recommended the establishment of a Task Group to study the variation between countries in rates of Decompression Illness resulting from altitude chamber exposure. In addition, they recommended that NATO validate the need for a new STANAG on Night Vision Training. All attendees also agreed on the need for a follow-up Workshop in 3-5 years to review the progress made on issues identified during this Workshop and to discuss methodologies for providing Aeromedical Training.

Les aspects aéromédicaux de la formation des équipages

(RTO MP-21)

Synthèse

La commission facteurs humains et médecine de l'Organisation pour la recherche et la défense de l'OTAN (RTO) a organisé un atelier avec des responsables de formation dans le domaine aéromédical pour discuter des programmes aéromédicaux de formation et présenter un certain nombre d'approches nouvelles. En outre, l'une des séances a porté sur une discussion des différentes approaches de la formation aéromédicale, avec examen du STANAG 3114 «La formation aéromédicale du personnel navigant». Les sujets suivants ont été abordés : les catégories de formation, les sujets enseignés, la périodicité de la formation, la durée des cours, la période de validité et les profils utilisés pour la caisson à dépression.

Les objectifs de l'atelier ont été atteints. La majorité des pays membres de l'OTAN, plus la Pologne et la République Tchèque étaient représentés et ont donné des résumés de leurs programmes. Des communications ont été présentées sur les nouvelles approches de la formation aéromédicale y compris : La formation en physiologie par simulateur (SYMPHYS), l'entraînement au simulateur et en vol sur la désorientation.

Les participants ont proposé un certain nombre de modifications à apporter au STANAG 3114, comprenant, de façon non-limitative : suppression de la distinction entre aéronefs à voilure fixe et à voilure tournante, adoption du principe d'une formation sur les aspects aéromédicaux des nouveaux équipements de survie et adoption du principe d'une séance pratique de désorientation spatiale lors des cours de recyclage.

Les participants ont également recommandé la création d'un groupe de travail pour étudier les différences entre pays concernant les incidences du mal de décompression résultant du passage en caissons à dépression. Par ailleurs, il ont souhaité que l'OTAN confirme la nécessité d'un nouveau STANAG sur l'entraînement à la vision nocturne. Un consensus s'est fait jour sur la tenue d'un atelier sur le même sujet dans 3 à 5 ans, afin de faire le point des progrès réalisés sur les questions identifiées lors de l'atelier et de discuter des méthodologies à adopter pour la formation des équipages.

Contents

† Paper not available at time of printing.

Preface

Are NATO countries complying with STANAG 3114 "Aeromedical Training of Flight Personnel"? Does STANAG 3114 require updating to ensure validity into the next century? These questions are frequently asked by Air Staffs and Aeromedical Training Personnel.

Following discussions at recent Aerospace Medical Association Meetings and the former AGARD Panel Meeting on "Selection and Training Advances in Aviation" held in Prague, Czech Republic in 1996 answers to the preceding questions were not readily apparent.

As a result this RTO Workshop invited Aeromedical Trainers from all NATO countries as well as PfP nations to discuss their countries' current Aeromedical Training Programmes and to discuss possible changes to STANAG 3114.

Workshop participants presented the current programmes in place in their countries for conducting Aeromedical Training. Presentations include aspects such as:

- Categories of Training
- Duration of Courses
- Frequency of Training
- Altitude Chamber profiles
- Subjects Taught

Additionally, there were presentations on new approaches to Aeromedical Training including Simulator Based Physiology Training, Simulator Based Disorientation Training and In-Flight Disorientation Training. The outcomes of the Workshop include:

- Recommendations for changes in STANAG 3114
- Recommendations for the RTO to form a Working Group to investigate the causes for the wide variation in DCI rates during training that has been reported in the various countries
- Recommendations that the NATO HFM validate the need for a new STANAG on Night Vision Device Training
- Recommendations that a simular workshop be convened in 3-4 years to review the Progress of this Workshop and to discuss methodologies for providing Aeromedical Training

Human Factors and Medicine Panel Officers

Chairman: Dr M.C. WALKER
Director, Centre for Human Sciences
F138 Bldg – Room 204
DERA
Farnborough, Hants GU14 0LX
United Kingdom

Deputy Chairman: Col. W.D. TIELEMANS
RNLAF/SGO
P O Box 20703
Binckhorstlaan, 135
2500 ES The Hague
The Netherlands

WORKSHOP DIRECTOR

Major Ken GLASS
Canadian Forces School of Aeromedical Training
17 Wing
P O Box 17000 Stn Forces
Winnipeg, MB R3J 3Y5
Canada
Tel: (1) 204 833 2500 ext 5877
Fax: (1) 204 833 2680
E-mail: kglass@vulcan.achq.dnd.ca

PANEL EXECUTIVE

Dr C. Wientjes
BP 25, 7 rue Ancelle
92201 Neuilly-sur-Seine Cedex
France
Tel: +33 (0)1 55 61 22 60/62
Fax: +33 (0)1 55 61 22 99/98
E-Mail: wientjesc@rta.nato.int

Aviation Medicine Training of Royal Air Force Aircrew

Wg Cdr C B Morris MB BS MmedSci MFOM DAvMed DRCOG RAF
Aviation Medicine Training Centre,
Royal Air Force Henlow,
Bedfordshire,
SG16 6DN
England

ABSTRACT

This paper opens with a brief history of aviation medicine training in the Royal Air Force (RAF). The details of courses currently run by the RAF Aviation Medicine Training Centre (AMTC) are included together with information about the practical content of each course. In addition, the paper includes specific details of hypobaric chamber profiles used at AMTC and covers the possible reasons behind the lack of decompression sickness incidents experienced by the RAF. The paper closes with an explanation of the internal audit procedure employed at AMTC.

INTRODUCTION

Aviation medicine training for Royal Air Force aircrew is carried out at the Aviation Medicine Training Center (AMTC). AMTC was formed in 1960 and in 1964 was located at RAF North Luffenham in the county of Rutland. It continued training there until Jan 98 when it transferred, on the closure of it's parent station, to RAF Henlow in Bedfordshire. In Dec 98 it will combine, at RAF Henlow, with the School of Aviation Medicine (SAM) from RAF Farnborough. The new unit will be known as the RAF Center of Aviation Medicine (RAF CAM).

COURSES

All aircrew-training courses are carried out with reference to Stanag 3114. Every aircrew course has its own official sponsor and the course syllabi are constructed with clearly defined aims and objectives. The approval and underwriting is then obtained from the sponsors and policy makers.

Essentially all aircrew attend AMTC for specific aviation medicine courses that are relevant, at the time of their attendance, to both their airforce career and their flying experience. The length of the course is obviously variable and can be from between one and five days. However, the underlying aim is naturally to make the courses as varied and as interesting as possible. To this end the courses are a mixture of lectures, discussion groups and practicals. The principal teaching medium used for presentations is Microsoft's PowerPoint and utilises embedded text, graphics, audio samples and video footage. VHS videos are shown where appropriate. The great advantage of this form of presentation is that generic course presentations can be easily adapted and modified to meet the students' actual knowledge and experience.

AMTC is also responsible for the initial sizing and fitting of aircrew equipment assemblies (AEA). Therefore all aircrew attending AMTC courses are checked to ascertain if any AEA is required. Should this be the case the necessary AEA is identified, and is then either issued or ordered.

It is also AMTC's mandate to be responsible for the anthopometric measurement of all aircrew in the RAF. It is a requirement therefore, for all aircrew attending AMTC to be measured against the general RAF entry standards and those specific to the aircraft they currently fly, or are going to fly. Anyone who falls outside clearly defined limits is identified and a relevant real-time aircraft cockpit check is arranged. Central policy staff then acts upon the outcome.

In 1997 AMTC ran a total of 295 courses with 2152 students. A table summarising the current aircrew courses is as per Annex A. Also included are samples of their templates and a breakdown of the topics. The current RAF's pilot training pathway is as per Annex B. This practically translates as a four day avmed introductory course and a three day Operation Conversion Unit course (one and a half days avmed and one and half days NBC).

PRACTICAL AVIATION MEDICINE TRAINING FOR AIRCREW AT AMTC

Hypobaric Chamber Training. Regular altitude training, with or without hypoxia experience, has been an integral part of aircrew aviation medicine in most countries for a long time. The underlying problem is that most of this specialised equipment is now showing its age and either upgrading or replacement is not an inexpensive exercise. This is exactly the situation the RAF found itself with the move of AMTC to RAF Henlow. Our situation was further compounded by the fact that we could not obtain UK national Health and Safety clearances with our chambers in their original configuration. The end result was that our chambers were upgraded, with the provision of additional safety features considered to be of paramount importance. Four layers of control mechanisms are now provided, together with a data recording facility and its printout. The first layer of control is an automatic option in which a selected chamber profile is chosen from a file server directory, with the chamber run then being directed under the control of an operator in a series of steps, each requiring a positive input. The second layer is a semi-automatic system where the operator can direct the chambers to ascend or descend at predetermined rates. Both the automatic and semi-automatic options operate with the valves being operated electrically. The third layer of control is a manual one with the valves operating pneumatically and this is essentially an emergency system. The fourth, and final layer of control, is the traditional turn-handle mechanism to open the descent valves manually. The routine aircrew training profiles are as follows:

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

a) Tucano. Climb to 25,000ft (no rapid decompression (RD)) at 10,000ft per min with hypoxia demonstration at 25,000ft. Descent is at 4,000ft per min.

b) Fast Jet (low level). Climb to 8,000ft at 4,000ft per min and RD from 8-25,000ft in 3 seconds with hypoxia demonstration at 25,000ft. Descent is at 4,000ft per min.

c) Multi-engined Transport. Climb to 8,000ft at 4,000ft per min and RD from 8-25,000ft in 12 seconds with hypoxia demonstration at 25,000ft. Descent is at 4,000ft per min.

d) Multi-engined Transport. Climb to 8,000ft at 4,000ft per min and RD from 8-25,000ft in 12 seconds with hypoxia demonstration at 25,000ft. Descent is at 10,000ft per min.

e) Fast Jet (high level). Climb to 18,000ft at 4,000ft per min and RD from 18-45,000ft in 3 seconds with hypoxia demonstration at 25,000ft. Descent is at 4,000ft per min.

The graphical representation of these profiles is in Annex C

The only run in which the students pre-oxygenate is the 18-45,000ft RD and is then 30 minutes on 100% oxygen. The students in this run subsequently select airmix when they descend below 18,000ft. On all the other runs the students are on airmix. Medical officer instructors perform all runs on 100% oxygen and select airmix on the descent below 18,000ft.

In 1997 a total of 1559 students were exposed to altitude in 279 chamber runs. Of this total 1264 students were subjected to a 25,000ft ceiling and 295 a 45,000ft ceiling. There were 225 low altitude runs (25,000ft max) and 54 high altitude runs (45,000ft max).

The prevalence of chamber incidents is both interesting and important. During the five year period 1983-1987 just five cases of simple DCS in students is reported by AMTC in over 12,000 exposures; giving a rate per 1,000 exposures of 0.41(1). In 1988 there were three cases reported and in 1989 none (2). Data is not available for the period 1990-1996, however during 1997 there were also no cases. The hyperbaric support facility at AMTC remains unused: AMTC celebrates its 34th anniversary this year. This lack of incidence is extremely interesting and warrants closer scrutiny, especially as other nations quote very different statistics. This could be caused by a number of factors, some of which are discussed below:

a) Inadequate briefing. We do not believe this to be the case as the instructors go to considerable length to ensure that this area is comprehensively covered.

b) Failure to own up to symptoms. This could definitely be relevant, especially as concerns regarding future employability cannot be completely dispelled. There is historical evidence that, in the RAF, the management of aircrew with training induced DCS has resulted in their re-role to the rotary fleet. However, this reluctance to own up should only be the case in type 1 & 2 DCS cases. One would expect types 3 & 4 DCS cases to be both identified by the student and diagnosed by the supervising instructors. One can certainly understand a reluctance to mention any perceived minor symptoms.

c) Failure to diagnose. We are confident that this is not the case.

d) Concerns regarding the treatment (usage of the hyperbaric chamber). We are confident that this is not the case.

e) Repeated exposure. Training exposure is kept to a minimum for the aircrew and a currency of five years is the RAF policy. Instructors are exposed to an average of three, and very occasionally four runs per week. Exposed to five runs in any one week is an extremely rare occurrence. The fact that instructors average tour length at AMTC is 3 years is of course relevant. We also do not perform an 'ear' check, as performed by some nations, as part of our routine profiles.

f) Time at altitude. We frequently perform CRs with less than the possible maximum of eight students, the average being four to six. Our hypoxia demonstrations are such that they are terminated at about 2min 30sec to 3min stage for each student, by which time we are confident that all the students will have experienced their important initial symptoms and have more than amply demonstrated a deterioration in their abilities. The end result of this policy is that the total duration of the runs, and especially the time above 18,000ft, is kept to a minimum.

g) Fitness of RAF aircrew. It would be tempting to state that RAF aircrew are so well selected, and hence so fit, that they do not possess any risk factors; however, I cannot say this with any degree of certainty!

h) Summary. I am unable to explain the complete lack of DCS incidents. However, I suspect that the answer is multi-factorial with failure to own up, diagnostic criteria, time at altitude and repeated exposures all contributing.

i) Other chamber incidents. AMTC did however have one significant incident in 1997 when an instructor became unconscious at almost exactly four minutes into the run. His students simply turning on his personal oxygen supply promptly rectified the problem!

Spatial Disorientation Training. Another presentation will cover this subject.

Night Vision Goggles Training. Another presentation will cover this subject.

Nuclear Biological and Chemical Training This training is given to aircrew at appropriate times in their career.

AUDIT

AMTC believes strongly in the audit process and this includes not only the performance of the instructional staff, but also all aspects of the aviation medicine courses. To meet these objectives AMTC has on its staff a professional education officer. Course critiques and debriefs are viewed as essential and are, therefore, obligatory for all courses. Any problems encountered, or relevant information gathered, are subsequently acted upon. Should it be identified that there is a deficiency in any aspect of the course then discussions ensue with the course sponsors and policy makers, and any appropriate action is then taken.

REFERENCES

1. Thornton E. The incidence of acute morbidity following exposure in a hypobaric chamber. Dissertation for Membership of the Faculty of Occupational Medicine of the Royal College of Physicians. May 88.
2. Harding R. DCS Experience Outside North America. Proceeding of the 1990 Hypobaric Decompression Sickness Workshop. October 1990

Annex A

AMTC Aircrew Courses - 1997

Basic Training Courses	Operational Conversion Unit	Continuation Training
Air Loadmaster Air Engineer Basic Navigator Basic Pilot Night Vision Courses	Fast Jet (e.g. Harrier, Hawk, Jaguar, Tornado F3 & GR1) Transport Aircraft (e.g. VC10, Hercules, E3D, Tri-Star) Rotary Aircraft(e.g. Puma, SeaKing, Chinook)	Fast Jet Transport Aircraft Rotary Aircraft Qualified Flying Instructor courses for Bulldog, Tucano & Hawk aircraft

Example of Basic Navigator Template

	DAY 1		
TIME	**LECTURE**		
830	ARRIVAL BRF		
840	ALTITUDE		
940	MEDICALS		
1025	TUC/DOMINIE OXY SYS		
1100	ACCELLERATION		
1200	**LUNCH**		
1330	ANTHROPOMETRY		
	HELMET FITTINGS		

	DAY 2		
TIME	**LECTURE**		
830	HELMET & MASK CHECK		
900	CHAMBER BRIEF		
915	CR 8-25		
1030	**COFFEE**		
1045	SENSES		
1200	**LUNCH**		
1300	PRESSURE BREATHING		
1330	PRESSURE		
1430	PRESSURE BREATHING		
1500	**COFFEE**		
1515	SURVIVAL		

	DAY 3		
TIME	**LECTURE**		
815	HELMET & MASK CHECK		
830	PRE OX		
900	CR 18-45k		
945	GYRO PRACTICAL		
1030	**COFFEE**		
1100	FATIGUE		
1200	**LUNCH**		
1300	AIRCREW HEALTH		
1400	CRM1		
1445	**COFFEE**		
1500	CRM2		
1545	CRM3		

	DAY 4		
TIME	**LECTURE**		
830	EXAM		
900	EXAM DEBRIEF		
930	COURSE DEBRIEF		
1000	**COFFEE**		
1130	AEA ISSUE		
1200			
LUNCH			
1330	AEA ISSUE		

	DAY 5		
TIME	**LECTURE**		
am	AEA ISSUE		
1200	**LUNCH**		
pm	AEA ISSUE		

Example for Refresher Training

	DAY 1		
TIME	**LECTURE**	**LOC'N**	**INST**
830	ARRIVAL BRIEF		
835	ALTITUDE		
930	**COFFEE**		
945	MEDICAL FITNESS & ANTHROPOMETRY		
1200			
LUNCH			
1300	PRESSURE BREATHING (a)		
1315	ACCELERATION (b)		
1415	PRESSURE BREATHING (a)		
1430	**COFFEE**		
1445	DISORIENTATION		
1530	GYRO PRACTICAL		

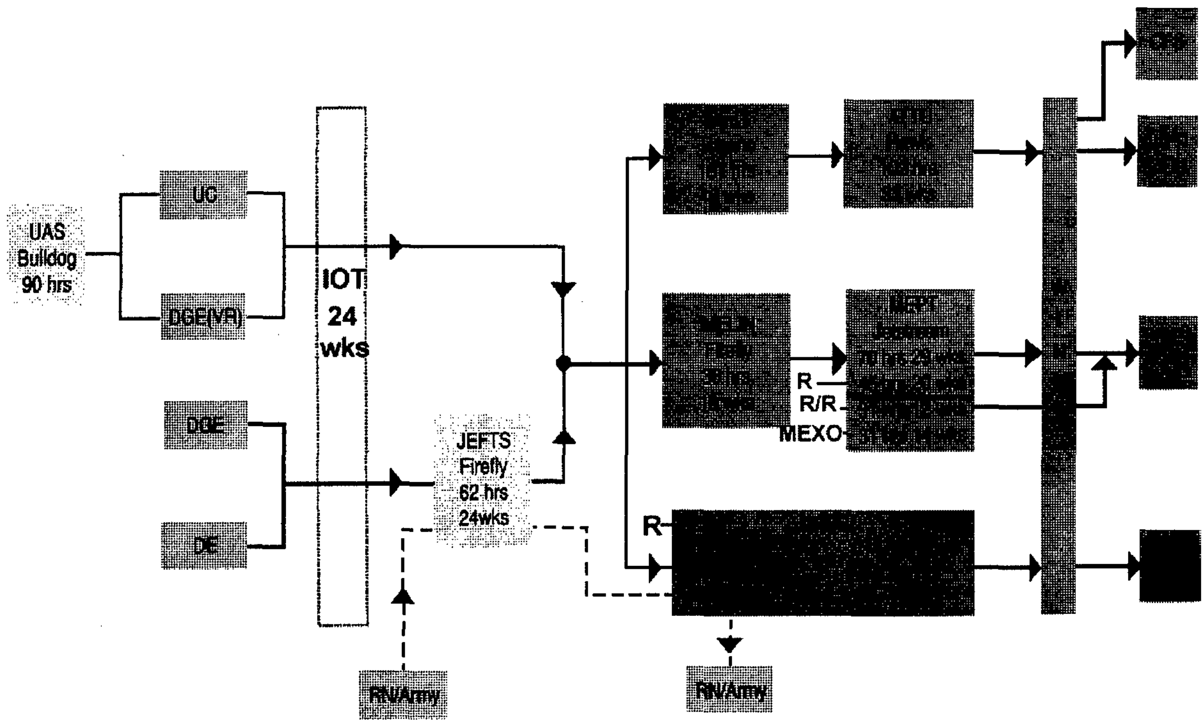
	DAY 2		
TIME	**LECTURE**	**LOC'N**	**INST**
815	HELMET & MASK CHECK		
830	PRE OX (IF REQUIRED)(a)		
900	CHAMBER RUN (c)		
1000	COFFEE		
1015	FATIGUE		
1100	COFFEE		
1115	AIRCREW HEALTH		
1200	DEBRIEF		
1215			
LUNCH			
1330	AEA ISSUE (IF REQUIRED)		

Notes:
1. a = for high level courses only
2. b = for appropriate courses only
3. c = appropriate chamber run for course

Topics	Subjects covered
Acceleration	Review of G effects, aspects of G-LOC, anti-G countermeasures, the push-pull effect and +Gz induced neck injuries.
Altitude	Physics of the atmosphere, oxygen requirements, hypoxia, hyperventilation, pressure changes and decompression sickness.
Aircrew Health	Aircrew Medical Examinations (including the investigations performed, alcohol risks and coronary artery disease) and Overseas Travel (including traveller's diarrhoea, malaria, hepatitis A & B and AIDS).
Crew Resource Management (CRM)	Review of the role of human factors in aircraft accidents, flight safety, operational effectiveness, decision making, situational awareness, communication, behaviour and personality.
Disorientation and Senses	Review of anatomy and physiology, limitations of the orientation senses, vision in flight, common problems encountered, coping mechanisms and motion sickness (physiology, signs and symptoms, prevention, adaptation and treatment)
Fatigue	Review of underlying physiological mechanism (circadian rhythm and sleep), signs and symptoms, management strategies, prevention and treatment.
Pressure	Review of Noise (incl. anatomy, physiology, protection, deafness), Vibration (incl. Physics, effects of, problems of) and Helmets (incl. Function, head protection, visors, communication system, oxygen system).
Survival	Review of physical environments (hot, cold, wet), first aid kit, ejection seats and aircrew clothing.

Annex B

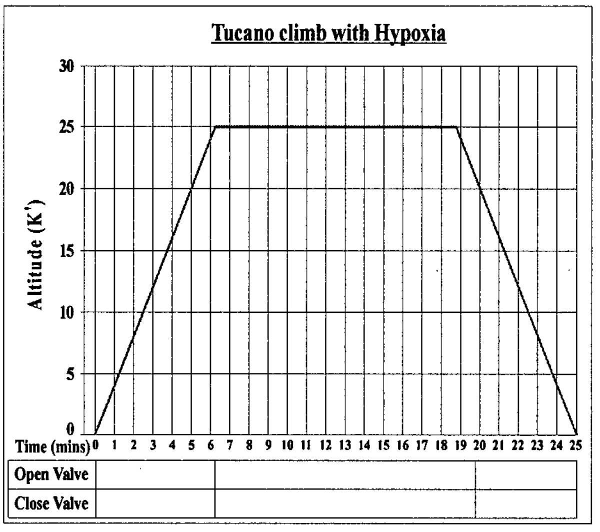
PILOT TRAINING PATTERN



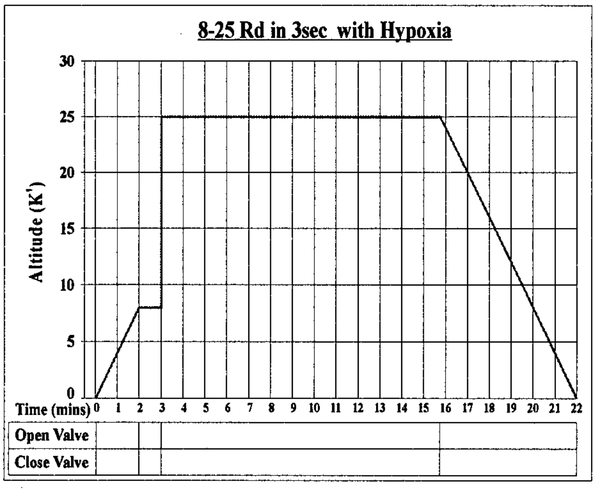
Notes
1. ● = Streaming point
2. R = Restreaming from Fast Jet or Rotary
3. R/R = Experienced aircrew cross over to Multi engined
4. MEXO = Restream from OCU
5. DGE (VR) = Direct Graduate Entry (Volunteer Reserve)
6. DGE = Direct Graduate Entry
7. DE = Direct Entry
8. FJ = Fast Jet. ME = Multi Engine. RW = Rotary Wing
9. RN inputs to Fast Jet stream not included
10. 1 wk AMTC inc prior to BFT\MELIN\DHFS gnd school
11. Suppory flying, flex and AI hours not included

Annex C

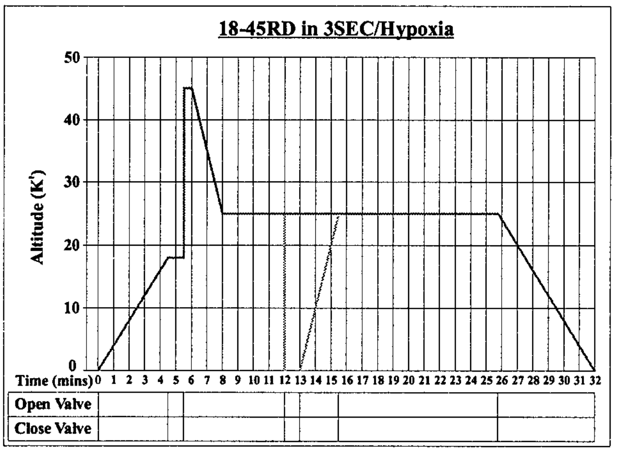
Profile A: Climb to 25,000ft (no rapid decompression (RD)) at 10,000ft per min with hypoxia demonstration at 25,000ft. Descent is at 4,000ft per min.



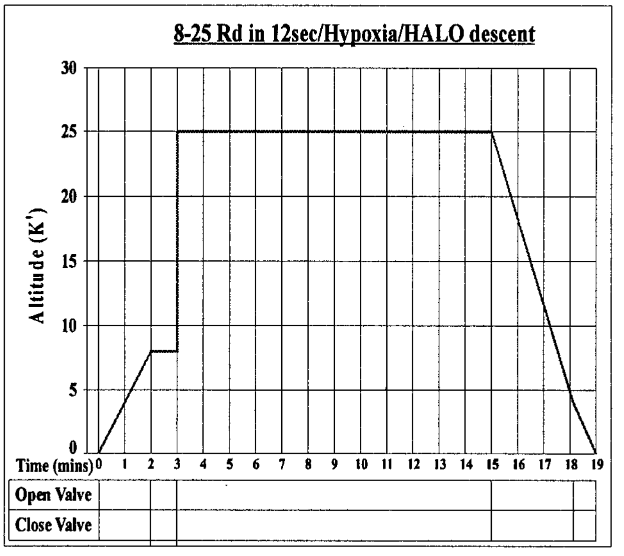
Profile B: Climb to 8,000ft at 4,000ft per min and RD from 8-25,000ft in 3 seconds with hypoxia demonstration at 25,000ft. Descent is at 4,000ft per min.



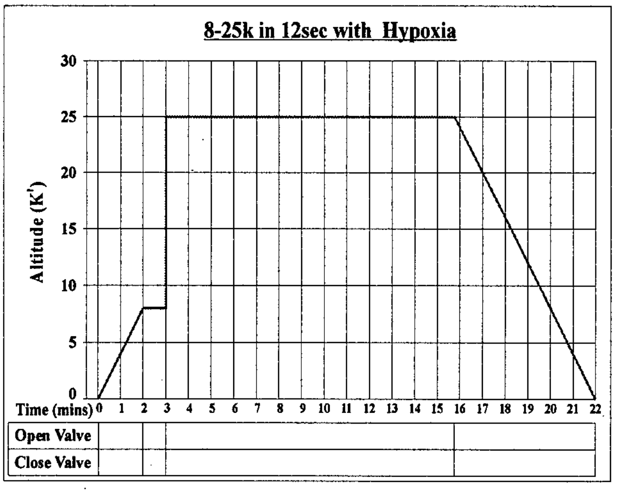
Profile E: Climb to 18,000ft at 4,000ft per min and RD from 18-45,000ft in 3 seconds with hypoxia demonstration at 25,000ft. Descent is at 4,000ft per min.



Profile C: Climb to 8,000ft at 4,000ft per min and RD from 8-25,000ft in 12 seconds with hypoxia demonstration at 25,000ft. Descent is at 4,000ft per min.



Profile D: Climb to 8,000ft at 4,000ft per min and RD from 8-25,000ft in 12 seconds with hypoxia demonstration at 25,000ft. Descent is at 10,000ft per min.



Spatial Disorientation Training of Royal Air Force Aircrew

Sqn Ldr D J Daulby BSc RAF (Retd)
Aviation Medicine Training Centre,
Royal Air Force Henlow,
Bedfordshire,
SG16 6DN
England

ABSTRACT

This paper gives the rationale behind the spatial disorientation training given to Royal Air Force (RAF) aircrew at the RAF Aviation Medicine Training Centre at Henlow. The link between aircrew roles, their experience levels and the training provided is explained and the content of the lecture programme is covered. Details of the practical training aircrews receive is included and the way the training is matched to individual requirements is explained. The paper ends with a brief look at the future of disorientation training within the RAF.

INTRODUCTION

Although the overall aircraft accident rate within the Royal Air Force is showing a satisfying reduction, a significant number of aircraft and aircrew continue to be lost through accidents involving a degree of spatial disorientation. Whilst the rate of such accidents is also reducing, in an effort to improve the situation further, the RAF has, within the last 2 years, updated its aircrew spatial disorientation training programme. This programme, run at the RAF's Aviation Medicine Training Centre (AMTC) at RAF Henlow, now consists of role-specific lectures in the physiology of orientation, which also include details of aircraft accidents exemplifying the consequences of failure to maintain spatial orientation, followed by practical spatial disorientation training in the Gyro-1 disorientation trainers. The intention of such training is to increase the effectiveness of aircrews' practical experience of spatial disorientation on the ground and hence, through education and awareness, reduce the number of incidents and accidents involving such disorientation.

In addition, it is also worth noting that this updated programme complies with the, recently promulgated, requirements of the Air Standardization Coordinating Committee (ASCC) AIR STANDARD 61/117/1 dated 17 July 1997. This Air Standard details the agreed minimal level of aircrew training in spatial disorientation required of ASCC member nations and has been ratified by the UK with one reservation; that the UK will not carry out refresher training at 4-yearly intervals.

AIRCREW ROLES AND EXPERIENCE LEVELS

The lecture programme developed at AMTC caters for 3 broad aircrew categories. These categories are fast jet, transport and rotary wing and both the lecture content and disorientation training in the Gyro-1 are tailored, as far as possible, to meet the specific requirements of each aircrew category. However, it is also accepted that, as aircrews are required to attend AMTC on a number of occasions throughout their service careers, there is, within the 3 categories, a wide spectrum of experience levels. Specifically, aircrews are required to attend AMTC prior to beginning their basic flying training, at the start of conversion onto a new aircraft type and at 5-yearly intervals thereafter, thus complying with the requirements of NATO STANAG 3114. Therefore, the lecture content used for either ab-initio or experienced aircrew has been modified to suit the specific audience. The fact that even very experienced aviators are susceptible to disorientation effects forms the rationale behind the continuation training required by the RAF. In addition, AMTC instructors appreciate that the need for disorientation training of pilot and non-pilot aircrew categories are somewhat different and the syllabus of training also takes this fact into account.

LECTURE CONTENT

All disorientation lectures given at AMTC are roughly 45 minutes in length and use Microsoft PowerPoint as a presentation tool. The aim of all the lectures is to give aircrews an appropriate level of information about how they are able to orientate themselves and to detail the shortcomings of their orientation system when it is required to operate in an airborne environment. In addition, the lectures cover some specific examples of what can happen when aircrews respond to misleading orientation cues and give some general advice on strategies that might help to reduce the effects of such cues.

The issue of the differing aircrew roles and experience levels is addressed in 2 main ways during the lecture phase of training. Inexperienced, ab-initio, aircrews are given considerably more detail on the physiology of orientation than that given to refresher students. However, all lectures cover, to an appropriate level, the physiology of vision and its shortcomings in an airborne environment, the vestibular apparatus and associated illusions and the inadequacies of the proprioceptive sensors. In addition, all aircrew categories are given advice on how best to avoid disorientation. If the audience consists primarily of pilots then more emphasis is placed on the effects of visual illusions, whereas a rear crew course will include details on the problem of airsickness and its prevention. The syllabus customises the lectures to specific aircrew roles primarily by using examples of aircraft accidents to illustrate the effects of disorientation that are appropriate

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

to the particular role in question. So, for example, a fast jet course would have the effect of vestibular illusions illustrated with a Tornado GR1 accident, whereas an incident involving a C-141 might be used for a transport course. Thus the lectures are made, as far as possible, relevant to the audience at which they are aimed with the intention of increasing the effectiveness of the theoretical phase of the training provided.

PRACTICAL SPATIAL DISORIENTATION TRAINING

Historically, the practical side of disorientation training at AMTC was restricted to experience in the relatively simple and unsophisticated "spin box". This equipment limitation somewhat reduced the effectiveness of aircrew ground-based training and, consequently, in late 1996, AMTC brought 2 Environmental Tectonics Corporation Gyro-1 disorientation trainers into operation. These trainers are designed to induce or simulate a number of spatial disorientation illusions in a realistic cockpit setting and come with a number of pre-loaded profiles. However, whilst the Gyro-1s in their "off-the-shelf" configuration proved a very welcome increase in the effectiveness of the practical aspects of disorientation training, experience of their operations proved that some modification of the available profiles was necessary. For example, a number of illusions or flight conditions (such as the g-excess illusion and high-speed, low-level flying) were not available and the profiles which were available were designed with an American audience in mind. Consequently, AMTC personnel have, over the last 18 months, introduced new profiles, including ones to simulate the g-excess illusion and the Coriolis illusion in low level flight. In addition, all the original Gyro-1 software programmes have been modified, either in minor ways by substituting, for example, voice-overs using an English military idiom, or by changing the flight parameters to simulate more realistic flight profiles for current British military operations. Table 1 contains details of the flight profiles currently in use at AMTC. All the profiles in use have been anglicised to some extent and the name in column 1 indicates how the profiles are identified within the software.

Name (a)	Illusion (b)	Duration (sec) (c)
Demo 1	Freefly to Land	3600
Demo 2	Black Hole	160
Demo 3	Somatogravic	170
Demo 4	Runway Width	70
Demo 5	Up-sloped	
Demo 6	False Horizon	124
Demo 7	Coriolis	270
Demo 8	Somatogyral	267
Demo 9	Occulogyral	189
Demo 10	Nystagmus	167
Demo 11	Autokinesis	177
Demo 12	Leans	135
Demo 13	Graveyard Spin	153
Demo 14	G-Excess	118
Demo 15	Pitch Down	110
FJDemo7	Fast Jet Low Level Coriolis	270

Table 1 : Current Gyro-1 Profiles

In addition to modifying the Gyro-1 profiles, AMTC has developed a matrix matching profiles with aircrew roles. The aim is to improve the effectiveness of the training provided by providing aircrews with profiles which most closely simulate not only the actual flight profiles they encounter in their daily operations, but also the illusions most relevant to their role and experience. Data on illusions experienced against aircrew role have been gathered "in-house" from a self-generated and on-going questionnaire completed by aircrew attending AMTC, and these data have been used to try to ensure that the training given in the Gyro-1 is both relevant and worthwhile. Table 2 contains details of the profiles matched against aircrew roles that are currently favoured during practical training sessions at AMTC.

Profile (a)	Ab-Initio Courses (b)	Fast-jet (c)	Transport (d)	Rotary Wing (e)
Demo 1				
Demo 2		✔	✔	✔
Demo 3		✔	✔	
Demo 4		✔	✔	✔
Demo 5		✔	✔	✔
Demo 6	✔	✔	✔	✔
Demo 7	✔	✔	✔	✔
Demo 8	✔	✔	✔	✔
Demo 9	✔	✔	✔	✔
Demo 10	✔	✔	✔	✔
Demo 11	✔	✔	✔	✔
Demo 12	✔	✔	✔	✔
Demo 13				
Demo 14	✔	✔		✔
Demo 15	✔	✔	✔	✔
FJDemo 7		✔		

Table 2 : Gyro Profiles Against Aircrew Roles

THE FUTURE

Although aircrews perceive the current programme of spatial disorientation training at AMTC as a major improvement on what was previously available, we believe that there is considerable scope for further development. All Gyro-1 profiles presently in use are based on an aeromodel of the PC-9 aircraft and the flight characteristics of the trainer are not representative of the aircraft in use in the RAF. We intend to use different aeromodels to form the basis for future profiles in order to mimic more accurately the performance of the aircraft types flown by the students undergoing the training. In addition, we intend to use any further disorientation data gathered from aircrew attending AMTC to produce profiles that more closely simulate the sorties and circumstances in which aircrews report instances of in-flight disorientation. The ultimate goal is to provide an opportunity for aircrews to experience the types of disorientation their fellow operators have reported in circumstances as similar as possible to those highlighted in the questionnaire. Thus, by awareness and experience, we hope reduce the number of accidents involving spatial disorientation, and hence to meet AMTC's overriding aim of making a positive contribution to flight safety within the RAF.

Night Vision Training of Royal Air Force Aircrew

Sqn Ldr N G Hansford MBChB MRCGP DAvMed RAF
Aviation Medicine Training Centre,
Royal Air Force Henlow,
Bedfordshire,
SG16 6DN
England

ABSTRACT

This paper offers a summary of the Night Operations Familiarization Course which is currently employed at the Royal Air Force (RAF) Aviation Medicine Training Centre. A brief history of the development of the course is followed by a summary of both the academic and practical aspects of the current syllabus. The paper ends with a look towards future developments in Electro-Optic Training within the RAF.

INTRODUCTION

Since 1991 the RAF has provided an introductory course for Night Vision Goggle (NVG) operators called the Night Operations Familiarization Course (NOFC). Initially this course was taught at the Institute of Aviation Medicine, RAF Farnborough by an experienced pilot from an operational Harrier squadron (1 Sqn). Later the course was moved to the RAF Aviation Medicine Training Centre (AMTC) where teaching was carried out solely by Medical Officer Instructors. As NVG operations became more widespread throughout the Service, the course was expanded both in terms of content and type of crews receiving instruction. Pilots, navigators and other airmen aircrew of fast jet, transport and rotary wing aircraft are now included in the student population.

Currently there is no STANAG specifying the necessary Aviation Medicine Training required by aircrew either during pre-NVG operations induction training or during continuation training. It is intended that the NOFC should give aircrew members a clear understanding of night vision physiology, including unaided night vision. The course also demonstrates the skills required to fit, adjust and focus NVG correctly and hence, to achieve optimal visual acuity. Whilst, by definition, a familiarization course, the NOFC is given to any operator who applies for training as well as ab initio aircrew prior to any NVG exposure. The overall mission is to improve flight safety by maximizing operational effectiveness and increasing aircrew awareness of potential hazards in the NVG flight environment.

CURRENT TRAINING

The NOFC at AMTC is currently provided in part by a Flight Medical Officer (FMO) but mainly by aircrew with a background of NVG operations. Training currently lasts for one day and consists of:

a. Physiology. This lecture describes subjects such as physiological responses of the human eye in reduced light environments, depth perception, visual illusions and eye protection.

b. NVG Design and Build. This lecture covers the design of NVG, sensitivity, field of view, filter technology and the relationship between unaided and NVG aided vision. It also details the predictable limitations of NVG such as "black hole" effect and degaining characteristics.

c. Assessment, Fitting and Adjustment of NVG. Using the relevant to type NVG, all aspects of controls including function, faults and alignment details are taught to enable students to adjust NVG correctly.

d. The NVG Environment and Aircraft. This package discusses NVG imagery including hazards of NVG flight such as differing terrain and inadvertent weather entry. All aspects of the aircraft environment are also covered and include external and cockpit lighting, as well as disorientation, scanning procedures and effects of weapons on NVG performance. Important points are illustrated by multinational accident / mishap reports wherever possible.

e. Terrain Models. This practical exercise allows students to practice their setting up skills and to experience the effects of differing light levels and directions as well as cultural features on NVG imagery. AMTC has invested in two new terrain models which should be in place by December 1998, whilst both will facilitate generic functions it is intended to adapt one board to enhance the demonstration of rotary wing hazards.

f. Human Factors in NVG Operations. The final session considers lessons already learned in NVG operations. Subjects dealt with include fatigue, crew co-operation and details of common incidents during NVG flight. A series of quotes and lessons from various NATO NVG operators concludes the presentation.

FUTURE DEVELOPMENTS IN ELECTRO-OPTIC (EO) TRAINING

a. EO Integration - Forward Looking Infra-Red (FLIR). Experience gained at a high price has shown the need for integrated NVG / FLIR sensor training when EO devices are introduced into service. The emphasis again should be to increase awareness of flight safety

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

hazards as well as the enhanced capability afforded by EO combinations with attention to which system is best used in various conditions.

b. Objective Before Flight NVG Testing. The RAF currently has three types of NVG in service and, although a great deal of effort and emphasis is placed on NVG training at AMTC and during Squadron work-ups, it seems that adjustment and resolution checks are often ad-hoc with no common standard. Currently, the First Line Service and Test Equipment is used to provide a simple test of NVG performance. Recent evaluation of the Hoffman 20/20 Test Equipment has revealed several advantages and has the capability to enhance NVG imagery when used correctly. A drive is currently underway to provide before flight objective assessment of acuity against NVG Snellen charts and of dynamic resolution.

c. Use of Computer Based Training. AMTC is undertaking to develop a range of CBT aids to include academic information, incident/accident reports and video material relating to EO training. It is hoped that it will be possible to provide a centralized focus for refresher training of combat ready crews with special emphasis on Human Factors and Disorientation during NVG operations.

d. Training Program Development and Audit. Efforts are currently being undertaken to make all NVG courses type specific and it is intended to develop a dedicated course for continuation NVG training which will evolve from the NOFC. Negotiation with the Air Warfare Center, flying training authorities and operational squadrons is ongoing in order to optimize the timing of NVG training and to provide a feedback loop regarding the validity and usefulness of the current NOFC syllabus. At present all courses are internally audited by means of student critiques but ultimately it is hoped that external review, particularly analysis of the flight safety statistics regarding NVG operations, will reveal a positive impact of the training being carried out.

CONCLUSIONS

EO flying is very much part of the future operational role of the RAF. By being proactive it is hoped that our crews can learn the lessons of past NVG operations without paying the high price that others have been forced to pay in order to gain experience. In conclusion, any attempt to maximize the capability and effectiveness of operational use of EO equipment must include an emphasis on physiological limitations and all the hazards of night flying. This will serve to remind aircrew that, to quote Col Bill Berkeley, the Director of the USAF Night Vision Program, "The only thing that truly turns night into day is the sun!"

AVIATION MEDICINE AND PHYSIOLOGY TRAINING IN THE BRITISH ARMY

M. G. Braithwaite
Headquarters Director Army Aviation
Middle Wallop, Hampshire, United Kingdom, SO20 8DY

1. INTRODUCTION

1.1 The mission of Army Aviation Medicine is to enhance the effectiveness of Army Aviation by promoting health and minimising the deleterious physical, psychological and pathological factors associated with flight. This is delivered by providing integrated operational aeromedical guidance, education, research, and analysis to optimize the fighting power of the force and enhance flight safety. The aeromedical training of aircrew is clearly a most important function.

1.2 An outline of the Aviation medicine and Physiology training given to British Army helicopter pilots is presented. Training for other aircrew is described in brief at the end of the paper.

2. ARMY PILOT TRAINING

2.1 The present Army pilot course comprises the flight instruction shown below. The total course lasts between 15 and 18 months depending on the time of year that a student is loaded onto the course.

- A flying grading assessment on the fixed wing "Firefly"
  (13 hours). This is part of the pilot selection process.
- Elementary flight training on "Firefly" (40 hours)
- Helicopter training on "Squirrel"
  - Basic flight training (35 hours)
  - Advanced flight training (32 hours)
  - Operational training phase (82 hours)
- Operational conversion training onto:
  - Lynx (37 hours)
  - Gazelle (32 hours)
  - Apache Attack Helicopter (due to commence in 2001)

3. CATEGORIES OF AEROMEDICAL TRAINING

3.1 Aeromedical training for pilots is conducted at the following times, and each will be described.

- Before elementary flight training
- Between elementary and helicopter flight training
- During the operational training phase
- Refresher training throughout a pilot's flying career.

3.2 Before elementary flight training

A short "in brief" on essential Aviation Medicine aspects is given to student pilots before elementary flight training. The following topics are covered:

- Fitting flying clothing (helmets and flight suits) and instruction on the daily inspection and care of the equipment.
- An exhortation to adopt healthy habits and life style (particularly the limitation of alcohol consumption).
- Instruction to bring all medical matters to the attention of the Specialist in Aviation Medicine (flight surgeon) sooner rather than later.

3.3 Between elementary and helicopter flight training

The main aeromedical training module is conducted at this stage. Student pilots attend a two day (16 hour) course taught by Army Specialists in Aviation Medicine using the facilities of the Royal Navy Air Medical School. Other survival aspects are covered immediately after this course. The training essentially follows NATO STANAG 3114 illustrating the physiology with examples within the Army Air Corp's theatre of operations. Each topic is described in brief below:

3.3.1 Introduction.

The requirement for aeromedical knowledge: *"Wonderful has been the development of the airplane, inconceivable has been the neglect of MAN in the airplane." - First line of the AIR SERVICE MEDICAL (U.S. War Department, 1919).*

3.3.2 Problems at altitude.

The physics of the atmosphere has been covered by this stage in meteorology and principles of flight classes during ground school and so is not repeated.

- Basic principles of respiration and circulation
- Physiology of hypoxia including hypoxia experience in a decompression chamber at 25,000 feet (a night vision demonstration is given at 10,000 feet during the descent).
- Hyperventilation
- Pressure effects
  - local effects (barotrauma)
  - decompression sickness (particularly the increased risk of decompression sickness following SCUBA diving).

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

3.3.3 Noise and Vibration

- Elementary physics
- Effects of noise and vibration
- Precautions against noise induced hearing loss (the importance of hearing conservation).

3.3.4 Impact acceleration

The effects of impact acceleration and elements of "Crash worthiness": CREEP

- Containment
- Restraint
- Environment
- Energy absorption
- Post-crash factors

Examples from the Aviation Medicine investigation of Army accidents are provided to illustrate these principles, emphasize the importance of safety equipment, and to give the students some information on the development of protection for them and their passengers.

3.3.5 Vision.

- The physics of light, and anatomy and physiology of the visual system.
- The elements of light, form, and colour.
- Factors affecting resolution of the visual image, (e.g. transmissivity of optical interfaces, contrast and refractive error.)
- Depth perception (binocular and monocular cues).
- Visual illusions.
- Eye protection (e.g. trauma, ultraviolet, laser)

Both day and night unaided vision are covered in this class. A specific Aviation Medicine lecture is also given as part of the NVG training later in the flying course (see below).

3.3.6 Spatial Disorientation and motion sickness.

The classroom syllabus follows both the STANAG 3114 [1] and ASCC AIR STANDARD 61/117/1 [2]. The lecture on vision precedes this class.

- The anatomy and physiology of vestibular apparatus and kinaesthetic system
- Vestibular illusions
- Psychological aspects (e.g. breakoff phenomenon)
- Preventive technology and strategies
- Overcoming (managing) spatial disorientation
- Demonstration on a Barany chair. All students experience at least one demonstration of the limitations of the orientation senses or a vestibular illusion, and observe other students.
- The film "Puzzling Perceptions" [3] is shown.

The British Army Spatial Disorientation sortie is conducted SD demonstration sortie is conducted during the operational training phase (see below).

- Basic physiology and effects of motion sickness.

3.3.7 Thermal Stress.

Army pilots receive a brief introduction to the extremes of temperature and the protective measures. When they deploy to the tropics or the arctic, they are given an additional brief.

3.3.8 Aircrew equipment

The principles of function and care of:

- Helmets
- Below neck assemblies (hot and cold weather, and immersion clothing)
- Personal NBC equipment

3.3.9 Fitness to fly:

"Freedom from any defect in physical or mental ability which might impair performance or lead to sudden incapacitation in flight." Topics covered include:

- Minor ailments
- Avoidance of self medication
- Alcohol and drugs
- Fatigue

As student pilots now have direct access to a medical officer who knows exactly what they are going through (all Army Specialists in Aviation Medicine are rated helicopter pilots), they are encouraged to make use of that advantage.

3.3.10. Toxicology

An introduction to the effects of exposure to common toxic substances encountered in military aviation, and the control of the hazard.

3.3.11. Casualty evacuation

British Army Aviation is not roled to routinely transport casualties. However, most aircrew will be tasked to transport casualties at some stage. Unfortunately, few Army aircrew get sufficient experience during their flying careers to become expert. The advantages and disadvantages of casualty evacuation, the associated hazards, and the desired relationship between aviation and medical services are therefore explicitly discussed.

3.3.12. Human Factors.

A psychologist presents an introduction to the psychological element of aviation which serves as an introduction to their further study of crew resource management as part of their general flight training.

3.3.13 All student pilots are issued with a locally produced "Handbook of Aviation Medicine for Army Aircrew"

3.4 Associated Training.

Soon after the aeromedical physiology module, Army aircrew undergo the following associated survival training:

- Underwater escape
- Short Term Air Supply System (STASS)
- The principles and a brief experience of land and sea survival
- First Aid is not routinely covered as all soldiers have annual individual training objectives in this subject Further and advanced instruction is provided on an ad hoc basis.

3.5 Aeromedical training during the operational flight training phase.

Specialists in Aviation Medicine provide instruction on the following topics during this phase of flight training:

3.5.1 Night vision goggle (NVG) training.

- A revision of unaided night visual function
- Advantages and limitations of visual function with NVGs
- Focussing techniques
- Visual illusions and the increased risk of spatial disorientation [4].
- Aeromedical issues associated with an increased helmet mass (e.g. helmet stability, neck strain).

3.5.2 The spatial disorientation demonstration sortie.

Following a short refresher brief on the mechanisms of SD, the students experience this innovative enhancement to the control of spatial disorientation [5] (and see paper 17 of these proceedings).

3.6. Refresher training throughout a pilot's flying career.

3.6.1. Rather than repeat all the Aviation Medicine topics every 4 years, a rolling annual programme of several topics is conducted by Regimental Specialists in Aviation Medicine. Where possible, these are based on recent current examples and, rather than providing didactic instruction, aircrew are encouraged to participate in open discussion.

3.6.2. There is no physiology programme upon change of aircraft type as British Army helicopters are not radically dissimilar. However, with the advent of the WAH-64D (Apache Attack helicopter) from 2001, it is intended to introduce the following topics as part of the operational conversion training:

- Forward looking infrared night vision system: an aeromedical appreciation of the limitations as well as advantages of this system.
- Situational awareness (SA). The Apache is not just an aircraft. It is a potent weapons platform, an airborne intelligence cell, and a battlefield management system. An enhanced awareness of the principles of SA and the consequences of poor maintenance of SA will be required.
- Long duration acceleration. The Apache can sustain 3.5 to 4 G during Air Combat Maneuvers. Pilots should be made aware of the hazard and possibly taught an anti-G straining maneuver.

4. OTHER AIRCREW

4.1. Air Door gunners who man the machine gun from the Lynx cabin and Winch Operators who are part of the crew of the Bell 212 helicopter receive an abbreviated course of instruction (2 hours) in the weakest part of the man-machine system - themselves.

5. FUTURE ENHANCEMENTS

5.1. The following enhancements to the physiology training programme for British Army helicopter pilots are planned:

5.1.1. Hypoxia demonstration.

The decompression chamber profile developed by the Royal Danish Air Force will be trialled and hopefully adopted.

5.1.2. Spatial disorientation episodes during flight simulator training.

Following exploratory work conducted by the author at the US Army Aeromedical Research Laboratory [6], scenarios will be introduced to the Lynx simulator training programme to enhance the awareness of pilots and promote strategies to prevent and overcome spatial disorientation.

5.1.3. Associated training.

It is anticipated that because of the deep attack role of the WAH-64D, enhanced training in combat survival and resistance to interrogation will be incorporated in the associated flight training syllabus.

5.1.4. Case-based training

An enhancement to the aeromedical training of all NATO aircrew would be the exchange of case-based (personal experience) examples between nations. Discussion of these type of events would readily illustrate the vital requirement of physiology training for all aircrew. However, nations with small air services are unable to generate sufficient "war stories" to illustrate all the lessons learned. Therefore, exchange is encouraged by means such as the Internet perhaps in the format shown at Annex A. Readers are encouraged to correspond with the author if they agree to this approach (or can offer an effective alternative).

6. REFERENCES.

1. Standard NATO Agreement (STANAG) No. 3114. Aeromedical Training of Flight Personnel.

2. Air Standardization Coordinating Committee. Aviation medicine/physiological training of aircrew in Spatial Disorientation. Air Standard No. 61/117. 1997.

3. "Puzzling Perceptions" - Services Sound and Vision Corporation (SSVC). (unpublished video film). SSVC Multimedia, Narcot Lane, Chalfont St. Peter, Gerrards Cross, Buckinghamshire, SL9 8TN, United Kingdom.,

4. Braithwaite MG, Douglass PK, Durnford SJ, Lucas G. The hazard of spatial disorientatiion during helicopter flight using night vision devices. Aviat, Space, Environ Medicine 1998; 69: 1038-1044.

5. Braithwaite MG. The British Army Air Corps in flight spatial disorientation demonstration sortie. Aviat, Space, Environ Medicine 1997; 68: 342-345.

6. Estrada A, Braithwaite MG, Gilreath SR, Johnson P, Manning JC. Spatial disorientation awareness training. Scenarios for U.S. Army aviators in visual flight simulators. Fort Rucker, AL: US Army Aeromedical Research Laboratory, 1998; USAARL Report No. 98-17.

DETAILS OF A PHYSIOLOGICAL INCIDENT / ACCIDENT

(To be used for Aeromedical training purposes ONLY)

Source (Nation / service): ....

Contact for further information:

Name: ....
Telephone: ....
Fax: ....
E-mail: ....

****

Details of the event should be "sanitized" to prevent identification of the accident / incident.

Type and model of aircraft: ....

Please provide written details of the accident / incident and if possible, photographs / diagrams or any other relevant material.

....
....
....
(more space than this.........)

****

As a result of this accident / incident, have there been any changes made in the following:

Aircraft technology ?

Aircrew equipment ?

Aircrew training ?

Operational procedures?

PLEASE DISSEMINATE THIS INFORMATION TO THE AEROMEDICAL TRAINING AUTHORITIES OF ALL NATO NATIONS.

PORTUGUESE PHYSIOLOGICAL TRAINING PROGRAM

Lcol **Nuno Ribeiro**
Chief of AMC Endocrination and Safety Department

Maj **Carlos Rocha**
Chief of PTU

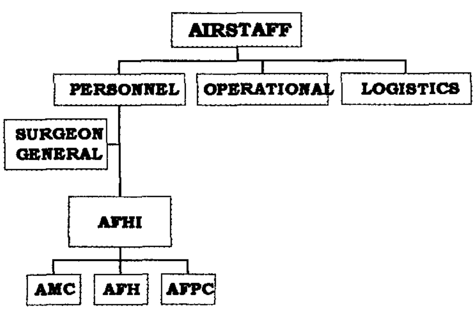
POAF/AEROMEDICAL CENTER
Azinhaga Torre do Fato
1600 LISBOA
PORTUGAL

Introduction

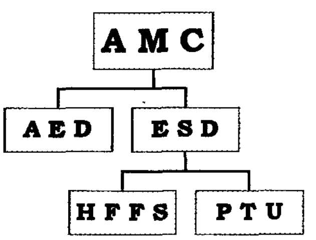
Aviation physiology training for Portuguese Air Force aircrew is carried out at the Physiological Training Unit (PTU) of the Aeromedical Center (AMC) since 1984 located at Lumiar Base in Lisbon.

For a better understanding of AMC integration we present the POAF organization with reference to the personnel branch and AMC struture.

POAF ORGANIZATION



AMC ORGANIZATION



Courses

All course programs of physiological training are based on the STANAG 3114.

We provide physiological training for all POAF crewmembers (pilots, navigators, flight engineers and in-flight operators), for same foreign military organizations, high altitude parachutists and a few civilian pilots.

The length of courses varies accordingly the type of aircrew duties. Usually the basic courses takes three and a half to four days and the refresher one-day.

The refresher occurs every 3 years for permanent crewmembers and 5 years for non-permanent crewmembers.

The syllabi of the refreshment is constructed to mach the aims and objectives defined in accordance with the type of aircraft and mission.

In 1997 AMC ran a total of 25 courses with 157 crewmembers.

Basic Courses Lectures

All lectures are performed using the *Microsoft Power Point* facility and videos when appropriate.

During classes students are requested to participate, talking about their own flight experience.

The Basic Course schedule integrate the following lectures:

- The Earth's Atmosphere
- Gas Laws
- Physiological Effects of Altitude
- Circulation and Hyperventilation
- Oxygen Systems
- Noise and Vibration
- Self Imposed Stress
- Egress
- G Forces
- Spatial Disorientation
- Situational Awareness
- Cabin Pressurization
- Problems of Vision
- Body Heat Balance
- First Aid

In **annex A** we include a breakdown of the topics.

Practical Training In Basic Courses

1. HYPOBARIC CHAMBER TRAINING.

Our chamber is a twelve seat model (Fig. 1), built in Portugal (Aeronautical Main Factory – OGMA) with two compartments: main chamber (8 seats) and lock (4seats). For rapid decompression training we have a

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

large vacuum accumulator connected to the chamber by two valves, one manual and other one electropneumatic.

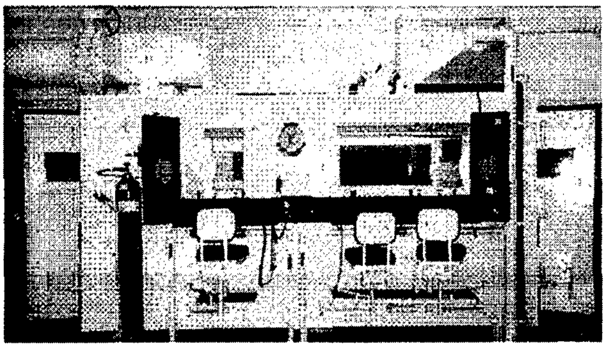


Fig. 1

The operation of climb and descend is manually controlled.

The profile used for basic training is presented in Fig.2.

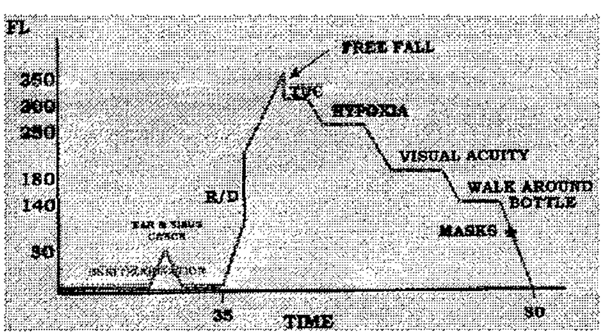


Fig. 2

Altitude chamber demonstrations:
- Rapid Decompressions
- Loss of Visual Acuity
- Hypoxia Symptoms
- Positive Pressure Breathing
- Walk Around Bottles
- Free Fall – Emergency Oxygen
- Parachute Opening Automatic Device

2. Spatial Demonstration Training

Statistics show that significant number of aircrafts accidents are related to Spatial Disorientation problems.

It's also proved that Spatial Disorientation

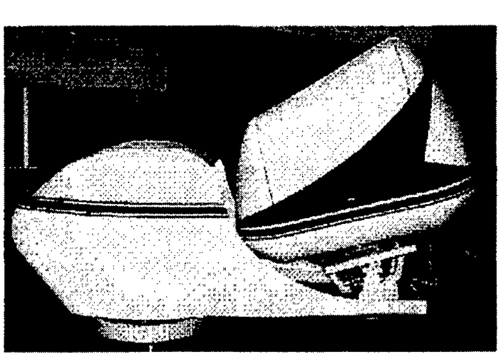


Fig. 3

Training improve the awareness of the role of orientation and show the students that the only way to deal with them is to rely on the instruments.

The AMC-PTU is equipped with two Spatial Disorientation demonstration devices, the GYROMAG (Fig. 3) and the Barany Chair (Fig. 4). Both were built under orientation of AMC-PTU, the first one in OGMA and the second one at AMC-PTU.

Fig. 4

TABLE 1 shows the performance characteristics of GYROMAG and TABLE 2 the common illusions experienced in flight.

TABLE 1
GYROMAG 87
PERFORMANCE CHARACTERISTICS

• Planetary Motion	0 to 25 rpm
• Cockpit Rotation	0 to 19 rpm
• Radial Acceleration	1,5 G's
• Pitch/Roll	40°
• Yaw	360°

TABLE 2
GYROMAG 87

Simulate common illusions experienced in flight, such as:
- Somatogravic Illusions
- Somatogyral Illusions
- Leans
- Coriolis

3. Night Vision Trainer

The problems of night vision, especially during night tactical flight, are a concern of crewmembers.

To demonstrate some of those threats we built a night vision demonstrator (Fig. 5) where we can discuss the following night vision problems:

- Monocular cues
- Night Vision Blind Spot
- Cloued and Fog Effects
- Flash Blindness
- Autokinetic Phenomenon
- Dark Adaptation
- Color Loss

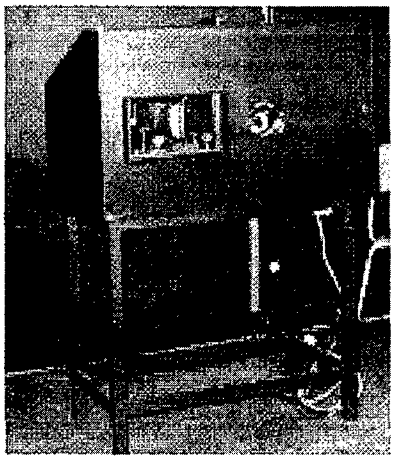


Fig. 5

4.EJECTION SEAT TRAINER (Fig. 6)

This type of training is done one time, in the first physiological course.

The aim of this training is to give the knowledge and conscious to the pilot of the importance of body postural during ejection.

Pilots who ejected from aircraft reported that the previous training was very helpful for the exit of Egress.

Fig. 6

TABLE 3 shows some features of the trainer.

TABLE 3
EJECTION SEAT TRAINER

• Manufacture Date	1984
• Maximum Capacity	9 G,s
• Normal Operation	6 G's
• Seat	According the type of aircraft

Refresher Courses

In accordance with the type of mission (fighter, transport or helicopter).

Example of a refresher for Fighters

Lectures:

- Hypoxia and Hyperventilation
- G Forces (G-Loc, Push-Pull effect, etc.)
- Spatial Disorientation and Situational Awareness
- Night Vision Problems
- Egress

Trainers:

- Altitude Chamber Profile (Fig. 7)
- Night Vision Demonstrations
- Spatial Disorientation Demonstration

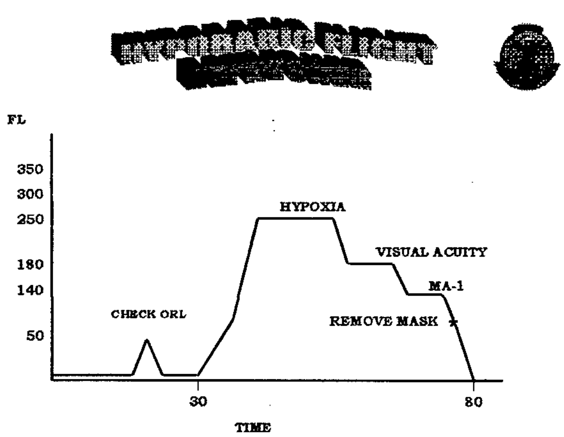


Fig. 7

TABLE 4 is an example of a Fighter Refresher Schedule

TABLE 4
FIGHTER REFRESHER PROGRAM

TIME	SUBJECT
0830 – 0930	Physiological Stresses Pressure Changes Hazards Trapped Gas Evolved Gas Hypoxia Hyperventilation
0935 –1000	Vision Problems Vision Trainer Demonstration
1005 – 1030	Self Imposed Stresses Noise And Vibration

1035 - 1230	"G" forces G-Loc Push Pull Effect Spatial Disorientation Situational Awareness
1230 - 1330	**LUNCH**
1330 - 1400	Oxygen Systems Pressure Breathing Training
1400 - 1530	Pre-Flight Briefing Chamber Flight Post Flight Briefing

Main bibliography used to prepare physiological training programs is shown in TABLE 5

TABLE 5
PHYSIOLOGICAL TRAINING
MAIN BIBLIOGRAPHY

- STANAG 3114
- AF PAMPHLET 160-5 1975
- AETC STUDY GUIDE/WORKBOOK 1993
- AFR 50-27 (C3) 1990
- ORIGINAL TRAINING (USAFSAM)
- REFRESHER TARF (USAFSAM)
- AIR FORCE INSTRUCTION(1-403) 1994
- AEROSPACE & HYPERBARIC PHYSIOLOGY (COL W. J. CAIRNEY; LTCOL JAMES P. DIXON)
- USAFSAM–TR–85-31 SPATIAL ORIENTATION IN FLIGHT
- AVIATION SPACE AND ENVIRONMENTAL MEDICINE
- AGARD WORKSHOP/SYMPOSIUMS/LECTURE SERIES PUBLICATIONS

ANEX A
PHYSIOLOGICAL TRAINING
BASIC COURSE PROGRAM

ATMOSPHERE AND GAS LAWS
- Atmospheric Characteristics
- Atmosphere Composition
- Types of Pressure
- Physical and Physiological Divisions
- Gas Laws

RESPIRATION AND CIRCULATION
- Phases of Respiration
- Anatomy and Physiology of Respiration System
- Control of Ventilation
- Anatomy and Physiology of Circulatory System

HYPOXIA AND HYPERVENTILATION
- Definition and Types of Hypoxia
- Objective and Subjective Symptoms
- Time of Useful Consciousness
- Treatment of Hypoxia
- Definition of Hyperventilation and Causes
- Characteristics of Hyperventilation
- Treatment of Hyperventilation

PHYSIOLOGICAL EFFECTS OF PRESSURE CHANGES
- Trapped Gas Disorders
  - Middle Ear
  - Sinuses
  - Gastrointestinal Tract
  - Barodontalgia
- Decompression Sickness (DCS)
  - Types of DCS and Symptoms
  - Factors Affecting DCS Incidence and Severity
  - Protection from DCS
  - Treatment of DCS

SELF-IMPOSED STRESS
- Self Medication
- Effects of *OTC* Drugs
- Types of *OTC* Drugs
- Alcohol and tobacco Use
- Nutrition (Hypoglycemia)
- Fatigue (Circadian Rhythm)
- Caffeine Use
- Stress Management

SPATIAL DISORIENTATION (SDO)
- Definition and Classification
- Orientation Sensory Systems
  - Visual
  - Vestibular
  - Somatosensory
- Vestibular Induced Spatial Disorientation
  - Somatogyral Illusions
  - Somatogravic Illusions
- Factors Affecting SDO
- Overcoming SDO
- Motion Sickness

SITUATIONAL AWARENESS
- Information
  - Awareness and Attention
- Lost of Situational Awareness
- Improving Situational Awareness

ACCELERATION
- Physical Principles and Types
- Types of Acceleration
- "G" Forces
- G-Induced Loss of Consciousness
- Protections Against G-Forces
- Physiological Factors
- The Role of Self-Imposed Stress

NOISE AND VIBRATION
- Definition and Characteristics of Noise
- Effects of Hazardous Noise
- Non-Auditory Effects of Noise
- Protections Against Noise Vibration
  - Effects and Symptoms of Exposure

VISION
- Anatomy and Function of the Eye
- Characteristics of Vision
  - Day Vision
  - Night Vision
- Visual Illusions
- Night Vision Demonstration

OXYGEN EQUIPMENT
- Oxygen Storage Systems
- Oxygen Delivery Systems
- Oxygen Mask and Helmet Assembles
- AIRCRAFT PRESSURIZATION
- Types of Pressurization Systems
  - Multiplace Aircraft
  - Fighter Aircraft
- Advantages and Disadvantages of pressurization Systems
- Decompression
  - Physical Indications
  - Physiological Effects
- Emergency Procedures

EGRESS
- Types of Ejection Systems
- Factors Affecting the Success of Ejection
- Human Factors: *Decision to Eject*
  - Pre-Ejection Considerations
  - Causes of Ejection Injures
- High Altitude Egress and Low Altitude Egress
- Simulator Training

FIRST-AID – SURVIVAL MEDICINE
- Bleeding
- Shock
- Injures
- Heat and Cold Exposures

United States Navy (USN) Aviation Survival Training Program

Commander Robert A. Matthews, MSC, USN
Bureau of Medicine and Surgery, Code 02T
2300 "E" Street NW
Washington, DC 20372-5120
USA

1. ABSTRACT

This paper describes the current USN aeromedical training program. Training requirements, training locations and training methodologies are listed. Details of curriculums, including topics, hours and training devices utilized are presented. Hypobaric chamber profiles for altitude simulations are also described.

2. PREFACE

The United States, Chief of Naval Operations (OPNAVIST 3710.7), requires initial aeromedical training for all persons prior to flight in naval aircraft. Subsequent refresher training is required every four years or upon significant lapse/change in aircraft currency or type. Specific training requirements are based on operational risks and vary depending on the status of the flyer. The US Navy, Bureau of Medicine and Surgery has responsibility for curriculum development and implementation. The United States Navy (USN)/United States Marine Corps (USMC) aeromedical training program is unique in that it encompasses water survival training as well as physiology, egress and survival issues.

Aviation Survival Training Centers (ASTCs) are located at the following locations:

Naval Air Station, Whidbey Island, WA
Naval Air Station, Lemoore, CA
Marine Corps Air Station, Miramar, CA
Naval Air Station, Pensacola, FL
Naval Air Station, Jacksonville, FL
Marine Corps Air Station, Cherry Point, NC
Naval Air Station, Norfolk, VA
Naval Air Station, Patuxent River, MD

In fiscal year 98 (Oct-Sep), the ASTCs trained 40,654 students in various aeromedical and safety courses. Courses are divided into INITIAL training and REFRESHER training.

3. TRAINING CURRICULUMS

Initial PHYSIOLOGY Courses:	Hours
NP1 – Perspective Aircrew (Pensacola)*	12-18
NP2 – Initial Aircrew (outside Pensacola)	12
NP3 – Selected Passengers	9
NP4 – Project Specialists	5.75
NP5 – Centrifuge Training	5
NP6 – Special Operations	2.5
NP7 – USN Midshipmen/VIP	5

*Initial for all Pilots/Naval Flight Officers

Initial WATER SURVIVAL Training

N1 – Perspective Aircrew	19.5
N2 – USN Midshipmen/VIP	3.5
N3 – Selected Passenger	8.5
N4 – Project Specialists	10
N5 – Non-crew on flight orders	8.5-15
N6 – Ejection Seat Aircrew Supplemental	10
N7 – Underwater Breathing Device	5
N8 – Basic Survival Swimming	2-17.5
N9 – Underwater Egress	4-6.5
N10 – Chem/Bio Egress	4.5

Refresher PHYSIOLOGY Training (4 year interval)

RP1 – Ejection Seat Aircrew	7.25
RP2 – Non Ejection/Pressurize Cabin	7.0
RP3 – Non-pressurize Cabin	6.25

Refresher WATER SURVIVAL Training

R1 – Ejection Seat Aircraft	10
R2 – Non-ejection/Parachute equipped	8.5
R3 – Non-parachute equipped	6.25

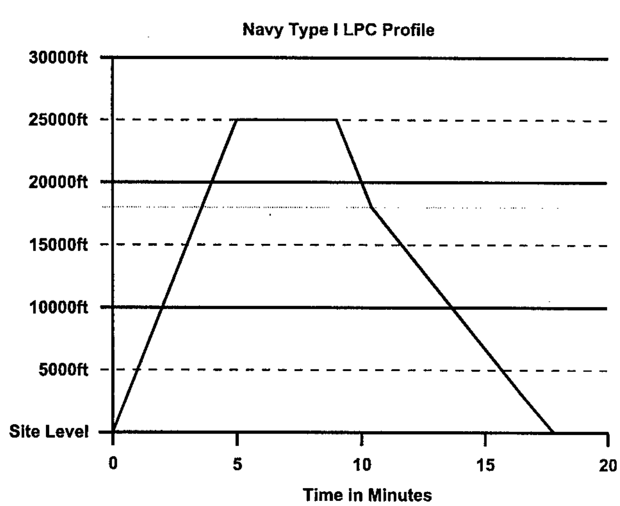
4. ACADEMIC TOPICS

Aeromedical Training is divided into six basic topics. Aviation Physiology, Stress/Human Performance, Sensory Physiology, Emergency Egress, Aviation Life Support Systems and Survival First Aid. The extent and content of each topic covered depends on the exposure to the threat each category of flyer expects to be exposed.

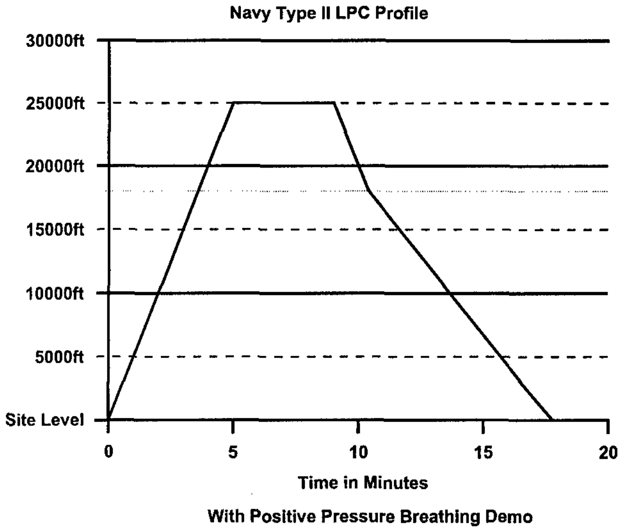
a. Aviation physiology addresses the physiological threats of the aviation environment, principles of cardiovascular and respiratory physiology including hypoxia, hyperventilation, gas expansion, gas evolutions and the need for oxygen systems. A hypobaric chamber is utilized as a dynamic training tool to expose students to an environment of reduced pressure and oxygen partial pressure.

Chamber profiles:

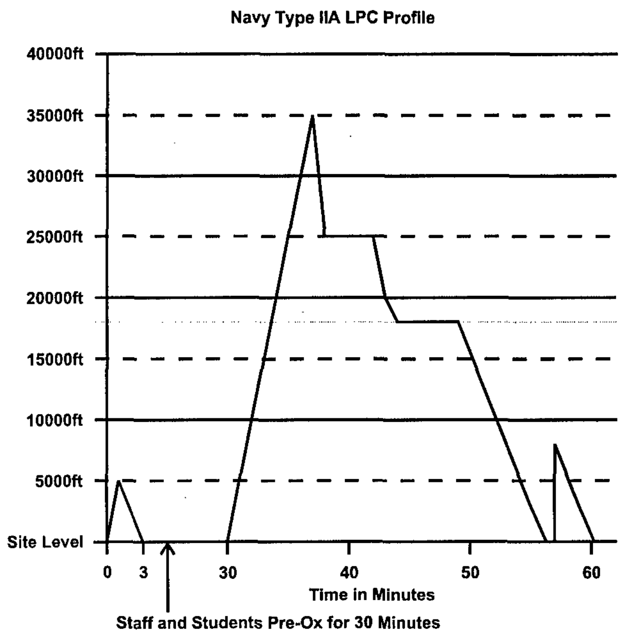
Type I 25K' Initial, non-pressure breathing



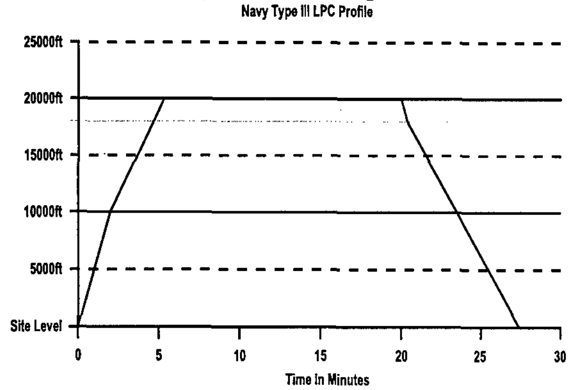
Type II 25K' Initial, 30 min pressure breathing at site level



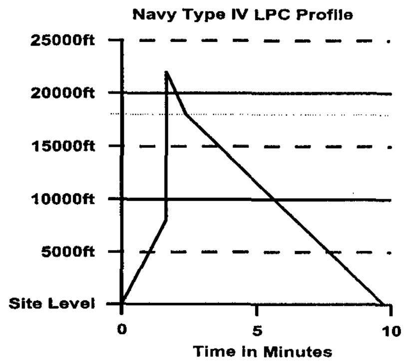
Type IIa 35K' USAF/USA Joint Initial, 30 min oxygen Pre-breath, ear/sinus check, hypoxia demos Rapid decompression



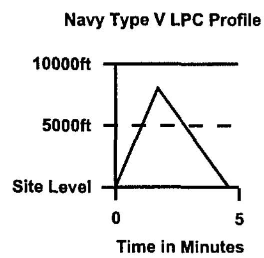
Type III 20K' Non-pressure breathing



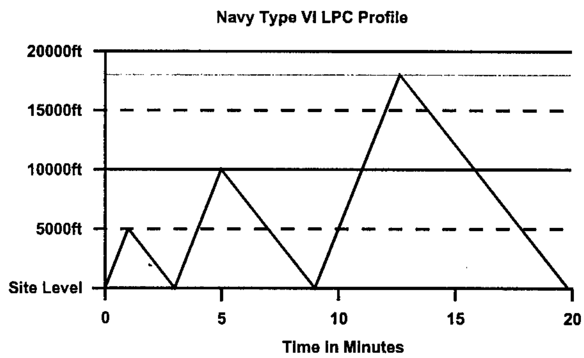
Type IV 22K' Rapid Decompression Profile (8K ->22K)



Type V 8K' Ear and Sinus Check



Type VI 18K' Medical Evaluation (5K, 10K, 18K)



b. Stress and human performance covers physiological, psychological, environmental, mission related stressors as well as stress management techniques. Sensory physiology addresses anatomy and physiology of the visual and vestibular systems.
c. Disorientation, temporal distortion, motion sickness and night vision systems are also discussed. For NP1 students, a Multi-place disorientation trainer (rotating platform with multiple rotating capsules) is used to demonstrate the disorienting effects of vestibular/visual conflicts of elevated inertial forces.
d. Emergency egress training involves discussions of the aeromedical aspects of ejection, ejection decisions, environmental hazards, parachuting and crash survivability. A dynamic ejection seat trainer is utilized to provide proper body position and dynamic force training.
e. Training in life support systems addresses flight, survival and rescue equipment. Survival avionics, signaling devices as well as special mission protective clothing are also addressed.
f. Basics in self-aid are covered in the emergency survival, first aid module. Hands-on practice is provided with injuries related to wounds, fractures, burns, bites and environmental exposure.

5. WATER SURVIVAL

Water survival training is an integral part of USN aeromedical training. Components of water survival training include;

a. Survival Swimming training and practice in survival swimming strokes and techniques (training tank).
b. Rescue equipment familiarization and in-water practice with flotation and signaling devices (Simulated helo hoist).
c. Underwater egress procedures and practice (Simulated multi-place underwater egress).
d. Underwater breathing device training (practice and execution).
e. Parachute descent/release procedures (simulated descent/drag)
f. First Aid
g. Extended sea survival techniques

6. CONCLUSION

In the future, the major objective of the USN aeromedical training program is to combine the physiology and water survival training courses into SINGLE curriculums. Each curriculum will cover survival and performance enhancement training, providing efficient, effective and platform specific training at the appropriate time for each aircrew. Additional the USN has initiated programs focusing on utilizing simulators and 'off the shelf' technology to improve training, especially in spatial disorientation and situational awareness. The USN is continuing to validate training requirements. These validations form the basis for training technology and content improvements to meet the US Naval Fleet survival training requirements.

Royal Danish Air Force Aviation Physiological Training Program

Julia N. S. Oldenburg, B.S.
Maj. Jan Nybo Nielsen, M.D.
Medical Squadron 590,
Vaerloese Air Base,
DK-3500 Vaerloese,
Denmark

ABSTRACT

This paper opens with a brief history of aviation physiological training in the Royal Danish Air Force (RDAF). The details of courses currently run by Medical Squadron 590 are included together with information about the content of each course. In addition, the paper includes specific details of the practical demonstrations provided to enhance learning and expand on the concepts taught during the theoretical portion of the course. The practical demonstrations included in all training courses are the unaided night vision and spatial disorientation demonstrations. An additional practical demonstration in the hypobaric chamber is included during courses for fighter (F-16), transport (C-130, G-III, Challenger, and NATO AWACS), helicopter (Westland Lynx), and high altitude parachutist (HAP) aircrew.

INTRODUCTION

In 1963, the Royal Danish Armed Forces Medical Services Branch received a hypobaric chamber from the United States. The logical choice at the time was to place the chamber at the military hospital in Copenhagen. On May 1st of 1964, after the assembly and completion of testing on the hypobaric chamber, formal training was instituted for all aircrew assigned to pressurized aircraft.

Today aviation physiology training is the responsibility of Medical Squadron 590, Vaerloese Air Base, which is located approximately 30 kilometers northwest of Copenhagen. The chamber is still located in Copenhagen, but it is owned by the Royal Danish Air Force (RDAF) and is operated by Medical Squadron 590. All theoretical lectures and practical demonstrations, other than chamber training, are conducted at Vaerloese Air Base and are the responsibility of Medical Squadron 590's personnel.

In 1993, the RDAF decided to broaden the scope of their aviation physiology training program to include courses for all aircrew assigned to helicopter and light aircraft. This decision to broaden the aviation physiological training program was to allow the program to meet the requirements stated in the NATO Standardization Agreement on Aeromedical Training of Flight Personnel (NATO STANAG 3114) and to meet U.S. Air Force physiological training acceptance criteria for those pilots who will be assigned flying duties on U.S. military aircraft (e.g. instructor pilots at Sheppard AFB, TX).

COURSES

Medical Squadron 590's Aviation Physiological Training section is responsible for training of all aircrew regardless of the branch of service assigned. Presently there are five different courses offered and aircrew are divided into groups based on aircraft type. Each course has its own syllabus and is constructed with clearly defined objectives. Since 1993, Medical Squadron 590 averaged 30 courses per year training approximately 40 fighter, 45 transport, 65 helicopter, 10 light aircraft, and 15 high altitude parachutist aircrew. An overview of the current aircrew courses along with course schedules is as per Annex A.

Essentially all aircrew attend specific aviation physiology courses that include information relevant to their aircraft type, aircrew position, and flying experience. The length of the course is dependent upon aircraft type. The fighter and transport classes are conducted over two days, whereas helicopter, light aircraft and the high altitude parachutist's courses are one day in length. The underlying aim is naturally to make the courses as varied and as interesting as possible. The courses consist of theoretical lectures, discussion groups and practical exercises. The principal teaching medium used for presentations is Microsoft's PowerPoint. The slide presentations are supplemented by showing training videos and Head-Up Display (HUD) tapes when appropriate. The greatest advantage is that all course presentations can be easily adapted and modified to meet the group's actual knowledge and experience.

PILOT TRAINING PATHWAY

All pilot candidates begin with the pilot screening program at Karup Air Base, Denmark. Following successful completion of the screening program RDAF pilot candidates receive a two-year officer course prior to continuing their flying training.

The official policy of the RDAF is that they only select and train fighter pilots. The Euro-NATO Joint Jet Pilot Training (ENJJPT) program at Sheppard AFB, Texas is the only training program used by the RDAF at the present time. Due to a shortage of pilots it has been considered that this be expanded to include the Royal Canadian Air Force's program. Acquisition of RDAF transport and rescue helicopter pilots is usually obtained through a transfer from the fighter squadrons. If requirements for transport or rescue helicopter pilots cannot be met then direct acquisition is temporarily used and follows either the army or the navy pathway.

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

The Royal Danish Army (RDA) and the Royal Danish Navy (RDN) selects only line or reserve officers to become pilots, which allows for better continuity in their flying training. After the screening program all pilot candidates are sent directly to initial helicopter training, U. S. Army and U. S. Navy respectively.

The last step in producing a fully qualified pilot lies in the specific aircraft type training (e.g. F-16, Lynx, H-500, and AS-550) or commonly referred to as operational conversion. Presently, all operational conversion training is conducted in Denmark and is the responsibility of respective service the pilot is assigned.

The current pilot training pathways are as per Annex B. Each pathway shows how a typical pilot candidate progresses from the initial pilot screening through operational conversion to become an airforce, navy or army pilot.

PRACTICAL TRAINING

Hypobaric Chamber Training

Training in the hypobaric chamber has traditionally been for those aircrew assigned to pressurized aircraft. In November of 1997, a profile for Navy Lynx aircrew was tested and approved for training. This new profile was instituted on request of the Royal Danish Navy. The need for a helicopter hypobaric chamber profile is based on the principle that the navy routinely flies above 10,000 feet during operations on Greenland. As of this date only 13 navy pilots and aircrew have participated in the hypobaric chamber. The results of the training so far are positive.

Presently there are four separate profiles used to train aircrew in the hypobaric chamber. The details of each profile and its graphical representation are per Annex C

Unaided Night Vision Training

In 1993, aviation physiology training was revised and expanded to include aircraft specific courses. An important part of this revision was the purchase of an unaided night vision training device developed by the U. S. Navy.

The purpose of the training is to give all aircrew an understanding of anatomy and physiology of the visual system and the limitations of the unaided eye at night. The demonstration is quite simple, but extremely effective. It utilizes specially filtered slides, which only allow enough light to pass through to be perceived by the fully dark adapted eye. As the demonstration progresses the students will begin to dark adapt and detect the text or pictures presented on each slide. The slide package is designed to teach anatomy, physiology, dark adaptation, limitations of night vision, and night vision scanning techniques.

Spatial Disorientation Training

In February 1997, the purchase of a spatial disorientation demonstrator (Gyro-I) added a valuable aspect to the practical portion of the course. The demonstrator can be used to allow aircrew to experience both vestibular and visual illusions. The intention of such training is to increase the effectiveness of the theoretical lectures.

Annex A

RDAF Aircrew Courses

1. Fighter Aircrew
2. Transport Aircrew
3. Helicopter Aircrew
4. Light Aircraft Aircrew
5. High Altitude Parachutist

Schedule: Fighter or Transport Aircrew

	DAY 1
TIME	LECTURE
900	Altitude Physiology - altitude & pressure - respiration & circulation - hypoxia & hyperventilation - trapped & evolved gases
950	Coffee Break
1000	Stress Factors - noise & hearing protection - thermal stress - fatigue issues - diet & exercise - alcohol & medicine use/misuse
1050	Coffee Break
1100	Stress Factors (Continued)
1145	Lunch Break
1230	Transport to Chamber Location
1300	Hypobaric Chamber Training
1500	End of Day 1

	DAY 2
TIME	LECTURE
900	Video Review of Hypoxia Demo
915	Human Performance Issues - situational awareness - attention management - acceleration (fighter only) - spatial disorientation
950	Coffee Break
1000	Human Performance Issues (Cont.)
1050	Coffee Break
1100	Gyro-I Spatial Disorientation Demo
1145	Lunch Break
1230	Unaided Night Vision Demo
1300	Aviation Psychologist Lecture - memory & cognition - perception - stress management - communication techniques - crew resource management
1350	Coffee Break
1400	Aviation Psychologist Lecture (Cont.)
1500	End of Day 2

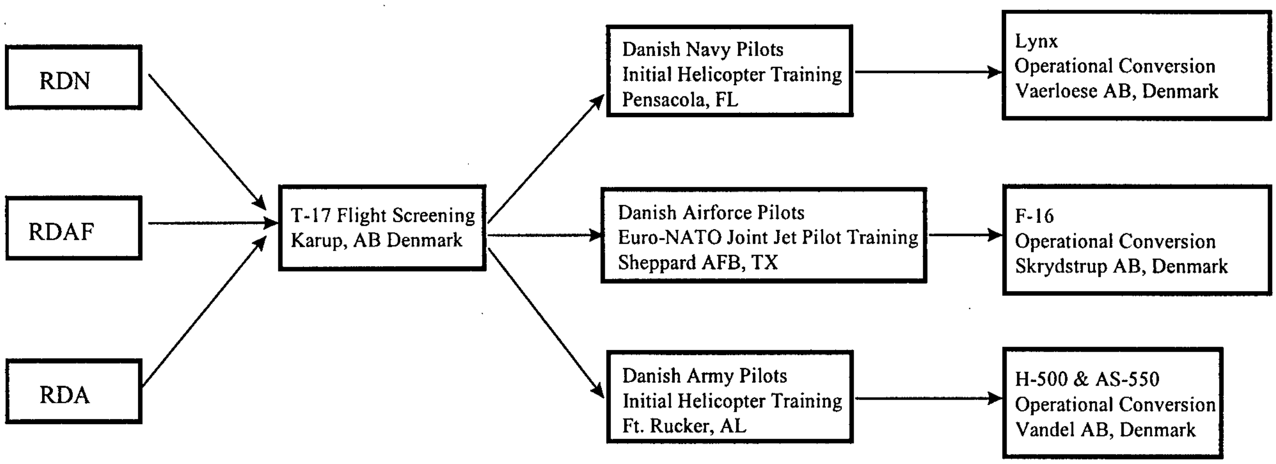
Schedule: Helicopter or Light Aircraft Aircrew

TIME	LECTURE
900	Altitude Physiology - altitude & pressure - respiration & circulation - hypoxia & hyperventilation - trapped & evolved gases
915	Stress Factors - noise & hearing protection - thermal stress - fatigue issues - diet & exercise - alcohol & medicine use/misuse
950	Coffee Break
1000	Human Performance Issues - situational awareness - attention management - spatial disorientation
1050	Coffee Break
1100	Gyro-I Spatial Disorientation Demo
1145	Lunch Break
1230	Unaided Night Vision Demo
1300	Aviation Psychologist Lecture - memory & cognition - perception - stress management - communication techniques - crew resource management
1350	Coffee Break
1400	Aviation Psychologist Lecture (Cont.)
1500	End of Course

Schedule: High Altitude Parachutist

TIME	LECTURE
900	Altitude Physiology - altitude & pressure - respiration & circulation - hypoxia & hyperventilation - trapped & evolved gases
950	Coffee Break
1000	Stress Factors - noise & hearing protection - thermal stress - fatigue issues - diet & exercise - alcohol & medicine use/misuse
1050	Coffee Break
1100	Unaided Night Vision Demo
1145	Lunch Break
1230	Transport to Chamber Location
1300	Hypobaric Chamber Training
1500	End of Course

Annex B



RDN
RDAF
RDA
T-17 Flight Screening
Karup, AB Denmark
Danish Navy Pilots
Initial Helicopter Training
Pensacola, FL
Danish Airforce Pilots
Euro-NATO Joint Jet Pilot Training
Sheppard AFB, TX
Danish Army Pilots
Initial Helicopter Training
Ft. Rucker, AL
Lynx
Operational Conversion
Vaerloese AB, Denmark
F-16
Operational Conversion
Skrydstrup AB, Denmark
H-500 & AS-550
Operational Conversion
Vandel AB, Denmark

Annex C

Fighter & Transport Main Chamber Profile

(1) In this profile all the participants breathe 100% oxygen for a total of 30 minutes below 10,000 feet to allow for protection against possibility of altitude induced decompression sickness. The pre-breathing period begins at ground level and after approximately 25 minutes an ear and sinus check is conducted.

(2) The ear and sinus check consists of an ascent to 6,000 feet followed by descent to just above ground level (AGL), to avoid breaking the chamber seal.

(3) If all participants are able to 'clear' their ears then an immediate maximum rate ascent to 25,000 feet (10,000 ft/min) is initiated.

(4) Upon reaching 25,000 feet the students are divided into two separate groups so that video tape recordings can be made. This allows the opportunity for students to experience personal hypoxia symptoms during the chamber flight and afterwards view the video for objective signs.

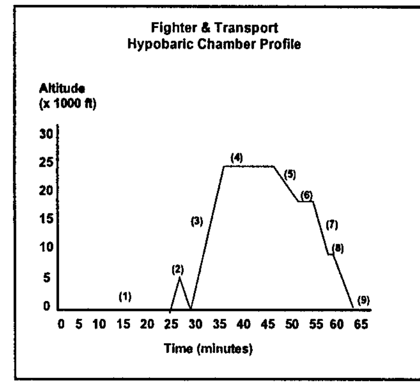
(5) The next portion of the chamber flight is a night visual hypoxia demonstration. This demonstration begins with a slow descent (2,000 ft/min) to 18,000 feet. When descending through 22,000 feet the participants are asked to remove their masks and the chamber lights are dimmed to cockpit illumination for night operations.

(6) Upon reaching 18,000 feet the chamber is leveled and a color wheel is given to each student. Students are instructed to hold the card at a normal reading distance and scan the card for two minutes. After two minutes the students are asked to continuing to look at the color wheel and hold their mask to their face breathing 100% oxygen. After one minute on oxygen the demonstration is concluded and the lights are brought back to normal illumination.

(7) Following the night visual acuity demonstration a descent to 10,000 feet (5,000 ft/min) is initiated. At this time all C-130 aircrew they will be asked to activate their emergency oxygen bottle.

(8) At 10,000 feet the chamber is leveled for the pressure breathing demonstration using the A-14 pressure demand regulator.

(9) The chamber flight concludes with a descent to GL and students are then divided into two groups for the rapid decompression profile.



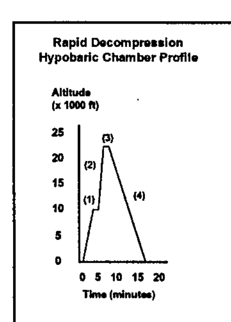
Fighter & Transport Rapid Decompression Profile

(1) In preparation for the demonstration the main chamber is evacuated to an altitude of 35,000 feet to allow the lock to decompress when the valve is opened between the two portions of the chamber. The students are then placed in the lock portion of the chamber and a climb to 8,000 feet (5,000 ft/min) is initiated. Upon reaching 8,000 feet the chamber is leveled and the instructor briefs the students on their emergency procedures.

(2) The instructor signals the chamber operator that they are prepared for the rapid decompression (RD). The chamber operator then presses a switch opening a valve, which causes the lock to decompress from 8,000 feet to 22,000 feet in one-half of a second.

(3) Following the RD the students are to appropriately apply their emergency procedures.

(4) When the instructor is assured that all students have applied the appropriate procedures a descent to GL (5,000 ft/min) is initiated. During the descent the instructor asks students to describe their own personal experiences.



High Altitude Parachutist's Profile

(1-4) This profile follows the same procedures as the fighter and transport profile up to the completion of the hypoxia demonstration at FL 250.

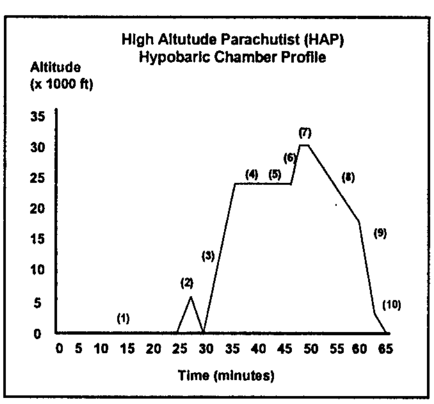
(5) At this juncture the profile varies in that students remain at FL 250 for an additional 10 minutes of 100% oxygen. This is to minimize any possibility of decompression sickness that may be induced by the second hypoxia demonstration at FL 300. The second demonstration is to simulate the procedures conducted during high altitude high opening or high altitude low opening (HAHO/HALO) operations.

(6) After 10 minutes on 100% oxygen a climb to 30,000 feet (5,000 ft/min) is initiated.

(7) Upon leveling at FL 300 the students are given a two-minute warning where they are to disconnect from the chamber oxygen supply and stand up. This simulates actual ramp procedures for HALO/HAHO operations.

(8) After two minutes a simulated HAHO descent is initiated and students are instructed to sit down.

(9) At 18,000 feet the descent is increased (10,000 ft/min) until 5,000 AGL where it is again slowed to avoid any ear and/or sinus problems.



Royal Danish Navy Helicopter Profile

This profile was created for the Royal Danish Navy and is designed to simulate Lynx helicopter operations on Greenland. The Lynx is the only Danish helicopter that routinely flies at altitudes that may pose a problem with hypoxia.

(1) The profile begins with an ear and sinus check to ensure that all participants can 'clear' during descent from altitude.

(2) Upon reaching GL a baseline heart rate and oxygen saturation for all students is recorded. This is done to show the subtle differences of altitude hypoxia to the students. These measurements are taken pre-flight at GL, and every 10 minutes at altitude for the duration of the profile, and again post flight at GL. The demonstration is quite long and minimization of boredom is crucial. This is accomplished by allowing the students to view a video during the first 20 minutes of the profile.

(3) A climb to 13,000 feet (3,000 ft/min) is then initiated. Upon passing 10,000ft the demonstration time is started. This is based on both military and civilian regulations, which limit unpressurized aircraft (not equipped with supplemental oxygen) to 30 minutes of flight between 10,000 and 13,000 feet. Our helicopter chamber profile is designed to simulate such a flight.

(4) The first heart rate and oxygen saturation at 13,000 feet is taken at the 10-minute mark.

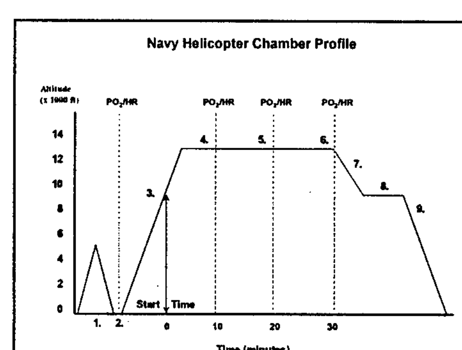
(5) The second heart rate and oxygen saturation at 13,000 feet is taken at the 20-minute mark. After 20 minutes of exposure to altitude the videotape is turned off and tests for mental and physical abilities are conducted.

(6) The third heart rate and oxygen saturation at 13,000 feet is taken at the 30-minute mark.

(7) Upon completion of the 30 minutes at altitude a descent to 10,000 feet is made.

(8) Upon reaching 10,000 feet the chamber lights are dimmed to simulate night flying conditions and a night visual hypoxia demonstration is conducted.

(9) Following the demonstration a descent to GL is initiated.



AVIATION PHYSIOLOGY TRAINING PROGRAMME OF CZECH AIR FORCE

LtCol. Petr DOŠEL, M.D.
Institute of Aviation Medicine, Prague, Gen. Píky 1, Prague 6, 160 60, Czech Republic

Summary

The lecture provides the basic information about aviation physiology training of the Czech Army. It takes notice of the circumstances of that system's development. There is emphasized that aviation physiology training system is approached to STANAG 3114 and there are presented the necessary changes in next future.

Text

Aviation physiology training programme of the Czech Army has been influenced by many structural changes of Czech Air Force during last eight years. That process has not been finished yet. Czechoslovak Army was divided at the time of dividing of Czechoslovak Federation Republic into Czech Republic and Slovak Republic in 1992. Of course all arms and weapon systems were divided according to agreed key. Czech Army sold MiG 29 aircraft to the Poland as a result of politician decision. Besides a flight lifetime of MiG 23 aircraft finished this year. It represents reduction of variety of aircraft types of Czech air force. As you can see on the scheme, Czech air force is armed by following types of aircraft:

A. Supersonic aircraft
   - Fighter: MiG 21
   - Bomber: SU 22
B. Subsonic bomber and combat aircraft
   - SU 25, L 29 and L 39.
C. Turbo-propeller training aircraft
   - Z 142

Most of combat's types are of Russian origin. All Czech aircraft (L 29, L 39, Z 142) are equipped with avionics, oxygen system, anti-g system and the other systems of Russian origin too. That's the reason, all military pilots use Russian special equipment and a garment at present too. Owing to that fact, it is necessary to keep our current valid regulations that describe of the use of above mentioned equipment. We are trying to change our aviation physiology training system and to approach it to STANAG 3114. We have already changed profiles of some examinations. The other ones we have to keep at the original form. We have been preparing some new changes of examinations but it depends on the innovation of our aircraft and a special equipment.

Our contemporary training system is then a compromise of both our previous system and a possibility of approaching to STANAG 3114. The lecture presents you the current situation and the possibility of development of Czech Army training system in future.

Czech pilot cadets are divided into two groups at the beginning of their career. The first group contains the flight personnel that operate fixed wing aircraft and second group the flight personnel that operate rotary wing aircraft. Pilots of the first group are more divided, during first two years of their training, into three groups: supersonic, subsonic and transport aircraft. Following table presents can see the summary of pilots' categories and corresponding medical categories.

Pilot of supersonic aircraft	LA1
Pilot of subsonic aircraft	LA2
Helicopter pilot	LB
Pilot of transport aircraft	LC
Pilot - contemporary unable for flying	LD
Pilot - permanent unable for flying	LDv

Training programme contains initial and continuation training for both groups. Both types of training include an academic instruction and practical examination or demonstration.

AVIATION PHYSIOLOGY TRAINING PROGRAMME

	Initial	Continuation
fixed wing aircraft	academic instruction	
	practical demonstration	
helicopter	academic instruction	
	practical demonstration	

Owing to a small number of our pilot cadets themes of academic instruction are equal for both groups of pilots. It's complicated for us to realize other various courses. For example this year there are 16 pilot cadets in the first year.

I. ACADEMIC INSTRUCTION

1) Initial course

Following scheme shows the list of the topics that are taught during initial training. Both content and extent of the theory are similar as in STANAG 3114 and include all basic topics:

- The Atmosphere
- Respiration and Circulation
- Hypoxia
- Hyperventilation
- Gas Expansion and Compression
- Decompression Sickness
- Oxygen Equipment and Special Equipment and Garment
- Cabin Pressurization
- Thermal Stress
- Acceleration
- Vibration
- Vision
- Hearing
- Orientation and Disorientation
- Air Sickness
- Human Performance
- Toxicology
- Survival and First Aid

2) Continuation course - Fixed Wing Aircraft

- Altitude and Oxygen Equipment, Special Garment

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

- Hypoxia
- Acceleration
- Thermal Stress
- Aircrew Health

3) Continuation course – Helicopter

- Altitude and Oxygen Equipment, Special Garment
- Hypoxia
- Vibration
- Thermal Stress
- Aircrew Health

II. PRACTICAL DEMONSTRATION AND TRAINING

1) Initial course - Fixed Wing Aircraft

That programme has been filling during four years of cadets' flying training.

A) The first year

Pilot cadets come to IAM for three days.

a) First day

First day all cadets are taken a global clinical and psychological examination. It means, internal, otorhinolaryngology, ophthalmology, neurology, surgery and other examinations. Examinations of vestibular system and stabilography run in the afternoon.

b) Second day

At the beginning we accomplish an anthropometric measurement of cadet's body and choice of a special equipment's size. We choose a size of anti-g trousers [PPK 6], special compensatory suit [VKK 6], full hermetic helmet [GS 6M], pilots' helmet [ZS 5] and oxygen mask [KM 32]. After that we do the individual fitting of mentioned equipment. Then we shortly repeat a theory about effects of hypoxia to the human organism. Each cadet is to undergo an exposure to reduced pressure in hypobaric chamber to a simulated altitude of 16 400 ft. Duration of a hypoxic exposure is 20 minutes. Cadets perform simple ophthalmological tests during hypoxic part of examination [for example contrast vision, color vision, stereoscopic vision and so on]. The aim of that examination is evaluation of cardiovascular response to defined load.

c) Third day

The first it is short control of knowledge of acceleration's effects to human organism. After that, it follows the evaluation of cadet's orthostatic efficiency using the LBNP method. In the end we do the final interview with each cadet.

B) The second year

Each cadet has just been taken an annual global clinical and psychological examination in second year.

C) The third year

Pilot cadets come to IAM for four days. Brief scheme of cadet's examinations during these days is presented.

a) First day

The first day is filled by annual global clinical examination.

b) Second day

- Psychological examination at the beginning.
- Short check of cadets' knowledge of acceleration effects.
- Practical training of anti-g maneuvers on the ground without acceleration exposure.
- A repeated training of anti-g maneuvers during an LBNP load at the end - cadets can persuade themselves how the amplitude of ear pulsation during the strain maneuvers increases.

c) Third day

- Practical training of using of special equipment and garment.
- Self-service of the fitting and adjustment of anti-g trousers, oxygen mask control and connection and so on.
- The basic examination is demonstration of changes of pressure and hypoxia. Each cadet is to undergo an exposure to reduced pressure in a hypobaric chamber to a simulated altitude of 25 000 ft. The profile of that examination is similar.

d) Fourth day

- Our hypobaric chambers aren't preparing for regular rapid decompression now. We have to realize only decompression with reduced velocity of atmospheric pressure change. The initial altitude is 8 000 ft., and final altitude is 25 000 ft. Duration of decompression is about 10 seconds. That's equal to the climbing velocity about 1 300 ft. per second.
- In the end we do the final interview with each cadet.

D) The fourth year

Each cadet has just been taken an annual global clinical and psychophysiological examination.

2) Continuation course - Fixed Wing Aircraft

Flight personnel are to attend a continuation training every fifth year. Length of course is two days.

a) First day

The members of flight personnel are taken annual global clinical and psychological examination.

b) Second day

The course includes short academic instructions and following practical examination:

- demonstration of change of pressure and hypoxia,
- positive pressure breathing.

3) Continuation course – Helicopter

The academic instruction is the same as at the first group. The practical examination includes only a demonstration of pressure's changes and hypoxia.

III.POSITIVE PRESSURE BREATHING TRAINING

Our pilots of combat aircraft train positive pressure breathing after finishing of basic flying training. We use following schedule of positive breathing training that corresponds to our contemporary valid regulations.

1) PD 2 - gradually increased positive pressure breathing on the ground simulator.

The first part is accomplished in high altitude compensatory suit and helmet with oxygen mask in the simulator on the ground. The level of the oxygen positive pressure is gradually increased - the values of positive pressure are: 29, 44, 58 and 74 torrs (600, 800, 1000 to 1200 mm of the water). The duration of the each step is five minutes.

2) K 16 - PPB training into hypobaric chamber - altitude 52 000 ft.

The second part is accomplished in the same accouterment but in the hypobaric chamber. The proband "climbs" to altitude 39 000 ft (positive pressure 29 torrs intrapulmonary). There he stays for three minutes to acclimatization for hyperbaric breathing. After that he climbs to altitude 46 000 ft (four minutes) (positive pressure about 50 torrs) and finally he goes to altitude 52 000 ft (three minutes) (positive pressure 75 torrs). The velocity of the climb is about 1604 feet per second (500 m/s). The velocity of the descent is maximal as soon as possible (usually 1600 feet per second 500 m/s) and on the altitude 19 000 ft. (6 000 m) we use the lower speed of descent - 500 ft. per second (150 m/s).

3) PD 3 - interrupted increased PPB on the ground simulator.

The third part is accomplished in high altitude compensatory suit and fullhermetic helmet of the accouterment. The level of the positive oxygen pressure is interrupt increased 59, 88, 118 and 147 torrs (800, 1200, 1600 to 2000 mm of the water). The duration of the each step is five minutes and the each brake five minutes too.

4) K 25 - PPB training into hypobaric chamber - altitude 86 000 ft.

The fourth part is accomplished in the same accouterment but in the hypobaric chamber. The proband "climbs" to altitude 39 000 ft (positive pressure 29 torrs). There he stays for three minutes to acclimatization for hyperbaric breathing. After that he climbs to altitude 82 000 ft (two minutes) (positive pressure is 147 torrs). The velocity of ascent and descent is the same as at K - 16 training and maximal as soon as possible.

FUTURE

The changes of our aviation physiology training programme depends fully on the way of the innovation of Czech Air Force. In the next future we will do following measures:

1. We are rebuilding the vacuum system of a hypobaric chamber to reach regular requirements of rapid decompression. The innovation will be finished this year.
2. We plan to buy the spatial disorientation simulator and to include the examination in this simulator to the routine training with an agreement to STANAG 3114.
3. Evaluation of $+G_z$ tolerance depends on the way of rearmament of Czech air force. In case of purchase high maneuvering aircraft (F 16, F 18, Mirage 2 000, Saab Grippen) will be necessary to include this examination into the routine training. The most probable decision it will be renting of an existing foreign human centrifuge for this examination.
4. The same it is going to demand on a change of the schedule of positive pressure breathing training. This change, of positive pressure breathing training, we will be able to realize immediately without any difficulties.

CANADIAN FORCES AEROMEDICAL TRAINING PROGRAMME

Maj K.C Glass
Canadian Forces School of Aeromedical Training
17 Wing, P.O. Box 17000 Stn Forces
Winnipeg, MB R3J 3Y5
Canada

INTRODUCTION

The Canadian Armed Forces has a long history of providing Aeromedical Training to its Flight Personnel. There have been as many as ten Physiology Training sites operating, including one in Lahr, Germany. In 1996, an amalgamation of the three remaining units was completed with the opening of the Canadian Forces School of Aeromedical Training in Winnipeg, Manitoba. This School is responsible for the conduct of all Aeromedical Training, Aircrew Survival Training, Basic Night Vision Device Training and provides Hyperbaric Chamber Treatments for military personnel and emergency civilian cases.

AEROMEDICAL TRAINING CATEGORIES

The Canadian Forces separates its Aeromedical Training into seven categories based on aircraft type.

Category A	Ejection Seat Aircraft Pilot
Category B	Non-Ejection Seat Fixed Wing Aircrew
Category D	Rotary Wing Aircrew
Category E	Ejection Seat Aircraft Crew
Category F	Ejection Seat Aircraft Passenger
Category G	Air Cadet Glider and Tow Plane Aircrew
Category H	High Altitude Parachutists

CATEGORY A TRAINING

This category requires a half-day of classroom training every five years, with chamber training every 10 years. Chamber training consists of a Type II chamber flight (fig. 2).

CATEGORY B TRAINING

This category requires a half-day of classroom training every five years, with chamber training every 10 years. Chamber training consists of a Type I (fig. 1c) chamber flight.

CATEGORY D TRAINING

This category requires a half-day of classroom training every five years, with a Type I (fig. 1b) chamber flight on Initial Training. No chamber training is required for refresher training.

CATEGORY E TRAINING

This category requires a half-day of classroom training every five years, with chamber training every 10 years. Chamber training consists of a Type I (fig. 1a) and Type III (fig. 3) chamber flight.

CATEGORY F TRAINING

This category requires a day of classroom training every two years. No chamber training is required.

CATEGORY G TRAINING

This category requires a half-day of classroom training and is provided annually to individuals taking part in the Air Cadet Gliding Programme.

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

CATEGORY H TRAINING

This category requires a half-day of classroom training every five years, with chamber training every 5 years. Chamber training consists of a HALO (fig. 5a) or Skyhawks (fig. 5b) chamber flight.

INITIAL TRAINING

Prior to commencing flight training, Canadian Forces Aircrew receive Initial Aeromedical training based on their crew position. To facilitate this the Canadian Forces School of Aeromedical Training conducts Basic Pilot, Basic Navigator, and Basic Aircrew and Rotary Wing Initial courses.

BASIC PILOT COURSE

This course is four days in duration and includes lectures and practical training sessions. Students undergo Type I (fig. 1b), II (fig. 2), III (fig. 3) and IV (fig. 4) chamber flights. In addition, all Basic Pilots receive practical Spatial Disorientation training in a Gyro IPT. The lectures range from Hypoxia to Motion Sickness (Table I) and cover all aircraft types.

BASIC NAVIGATOR COURSE

This course is three days in duration and includes lectures and practical training sessions. Students undergo Type I (fig. 1b) and IV (fig. 4) chamber flights. In addition, all Basic Navigators receive practical Spatial Disorientation training in a Gyro IPT. The lectures range from Hypoxia to Motion Sickness (Table I) and cover all aircraft types except ejection seat aircraft.

BASIC AIRCREW COURSE

This course is two days in duration and includes lectures and practical training sessions. Students undergo Type I (fig. 1b) and IV (fig. 4) chamber flights. The lectures range from Hypoxia to Motion Sickness (Table I) and cover all pressurized and non-pressurized fixed-wing aircraft types except ejection seat aircraft.

ROTARY WING INITIAL COURSE

This course is two days in duration and includes lectures and practical training sessions. Students undergo a Type I (fig. 1b) chamber flight. The lectures range from Hypoxia to Motion Sickness (Table I) and are specific to rotary wing aircraft.

Topics	Subjects Covered
Altitude	Physics of the atmosphere, oxygen requirements, hypoxia, hyperventilation, trapped and evolved gas problems and cabin pressurization
Disorientation and Senses	Basic anatomy and physiology, limitations of the orientation senses, vision in flight, motion sickness, noise and vibration
Life Support Equipment	Oxygen equipment and flight clothing
Acceleration	G effects, aspects of GLOC, anti-G countermeasures and the push-pull effect
Aircrew Health	Lifestyle issues including alcohol, smoking and diet, thermal stress and injuries related to heat and cold
Fatigue	Causes, signs and symptoms, management strategies, prevention and treatment
Ejection	Mechanisms of injury, body positioning, landing positions and decision to eject
Night Vision Goggles	Advantages and disadvantages, focusing and optimizing their use

Table 1. Aeromedical Training Course Subjects

CONCLUSIONS

The Canadian Forces is committed to providing its aircrew with the Aeromedical Training necessary to maximize their performance in the aircraft. Training is provided in accordance with STANAG 3114 at appropriate times throughout an aircrew member's career.

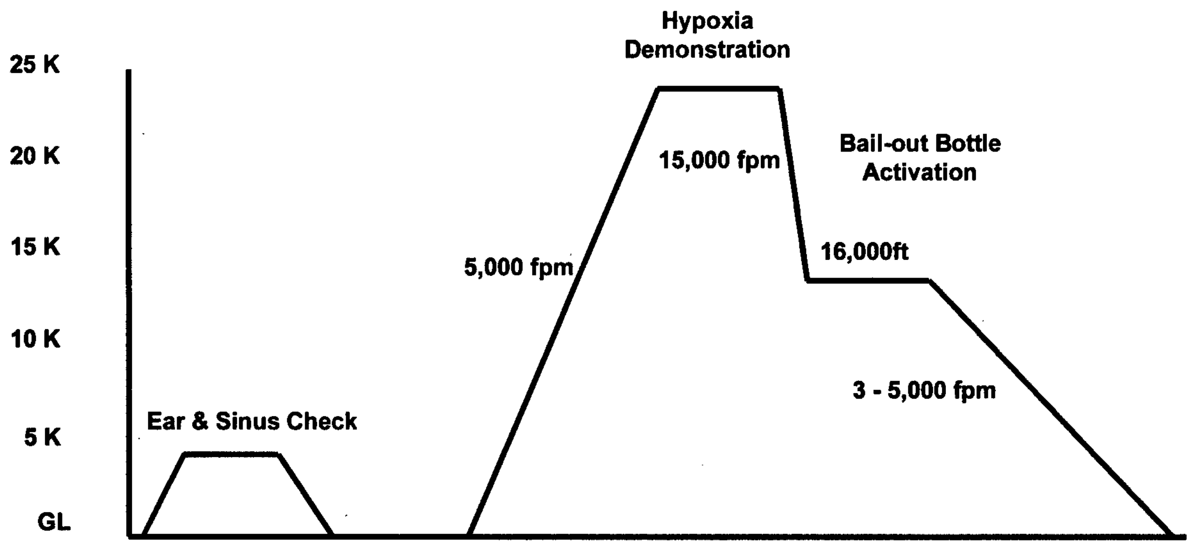


Figure 1a. Type 1A Profile 25,000 feet

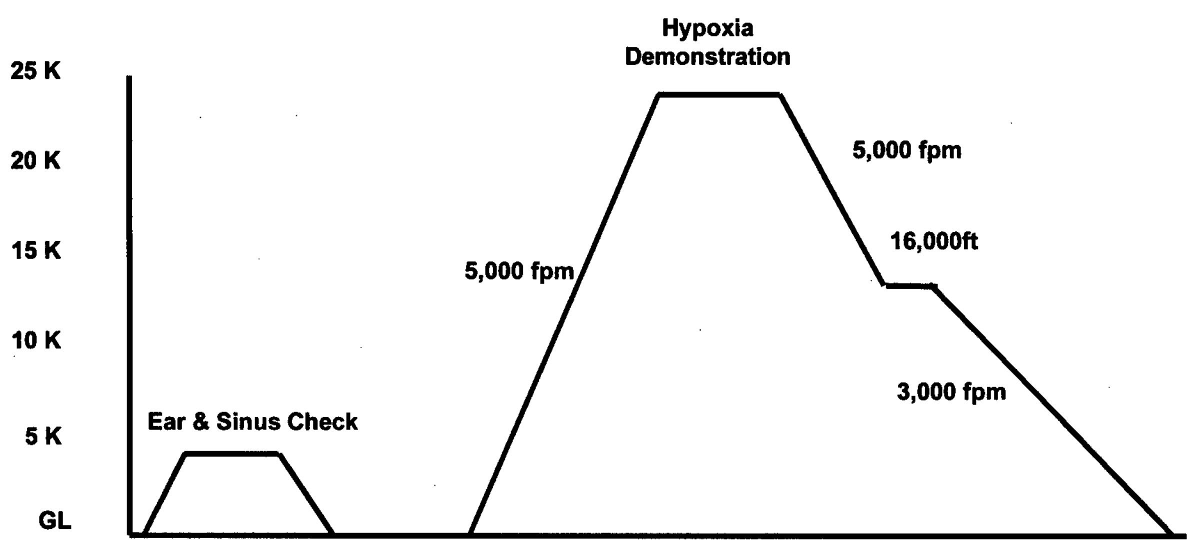


Figure 1b. Type 1B Profile 25,000 feet

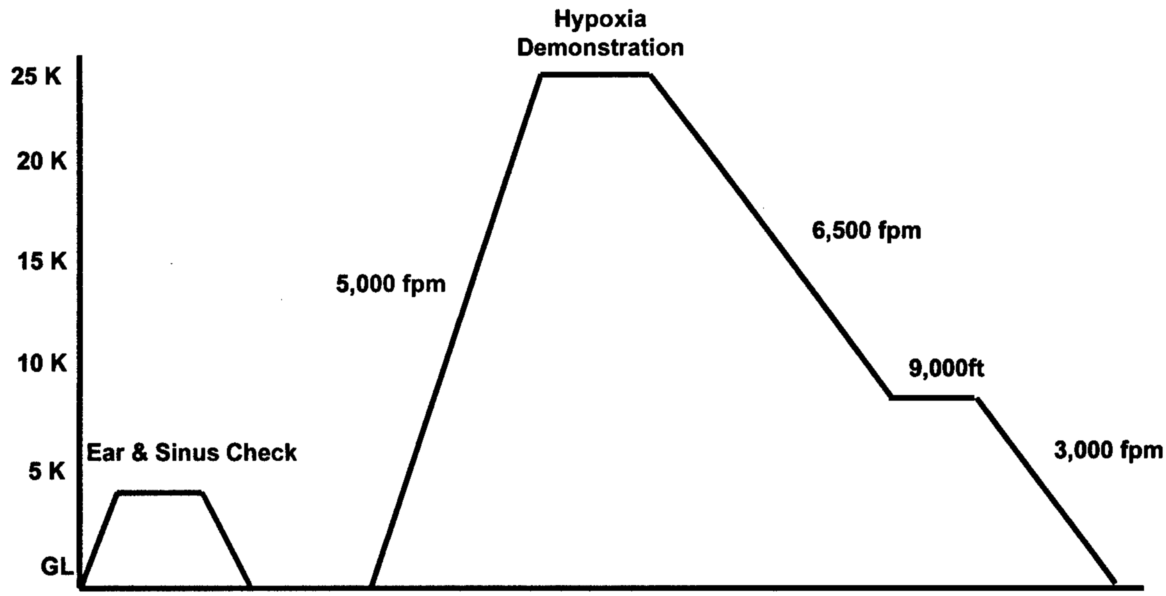


Figure 1c. Type 1C Profile 25,000 feet

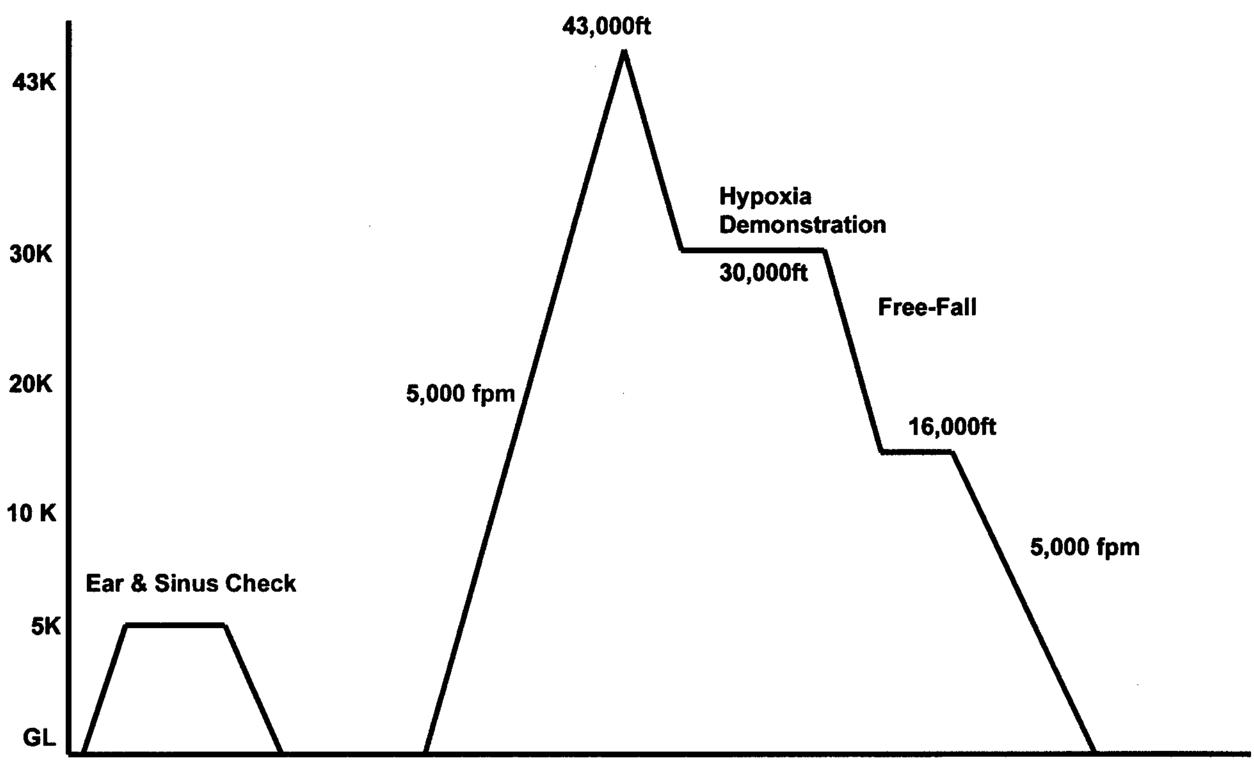


Figure 2. Type II Profile 43,000 feet

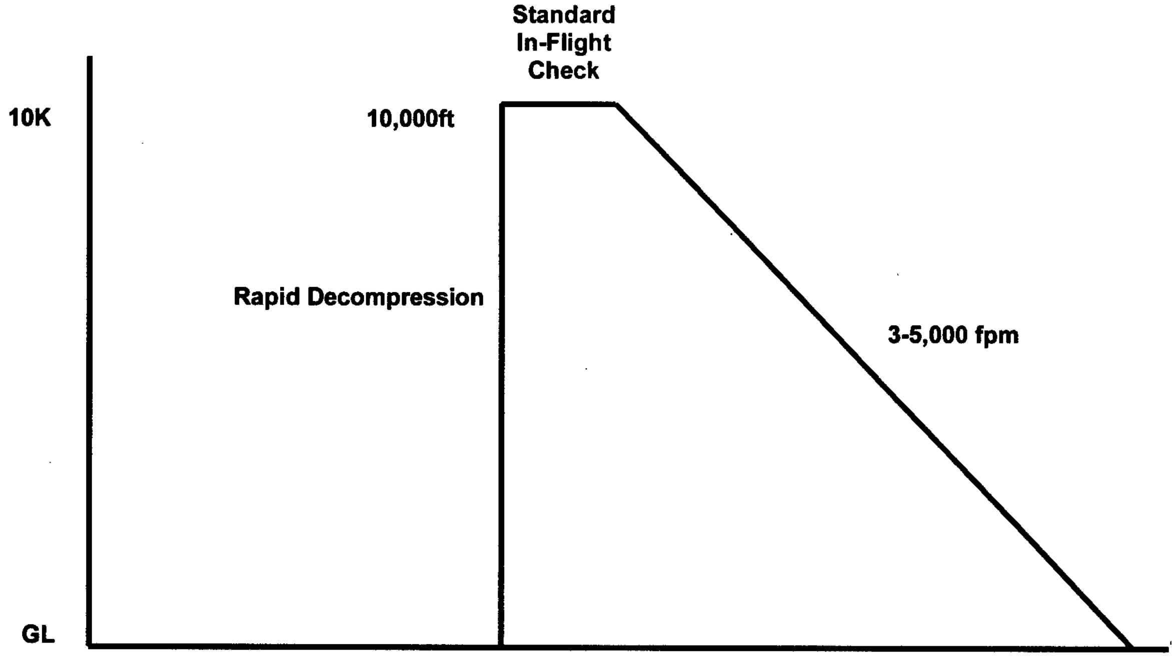


Figure 3. Type III Profile 10,000ft

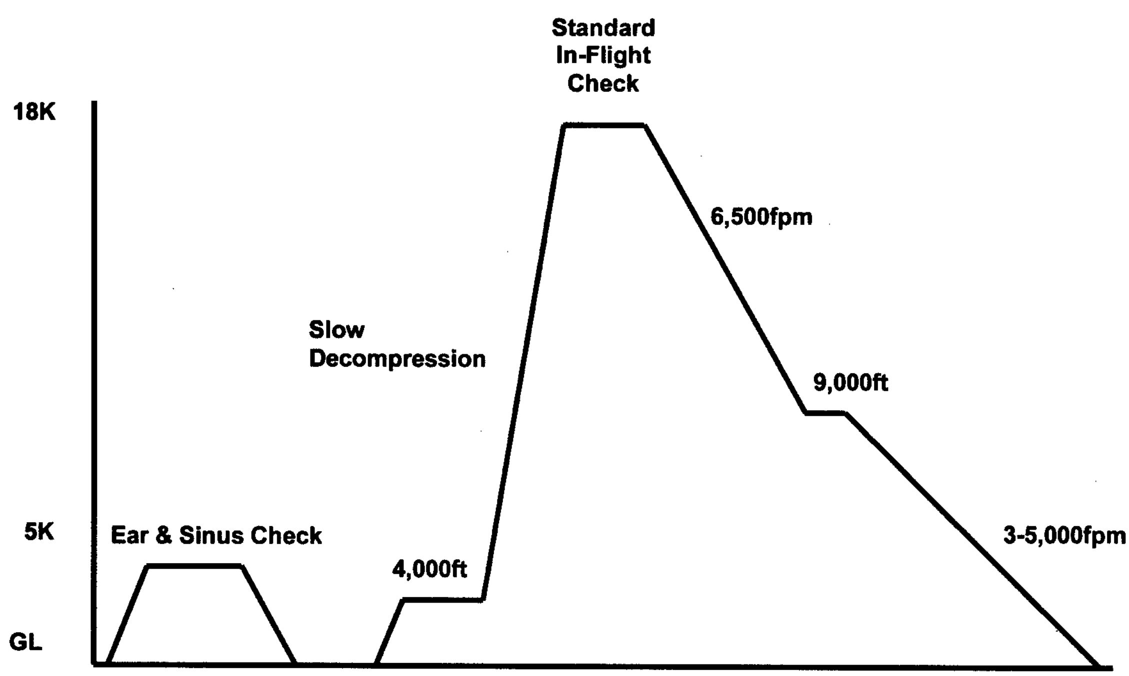


Figure 4. Type IV Profile 18,000ft

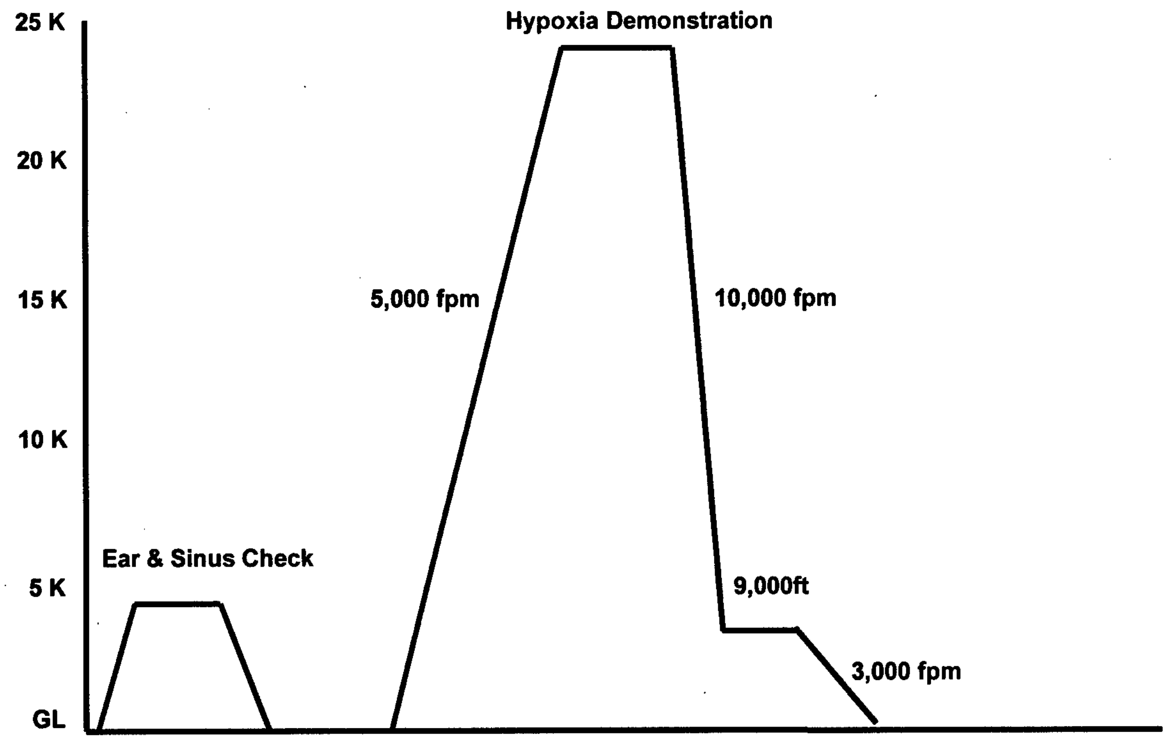


Figure 5a. HALO Profile 25,000 feet

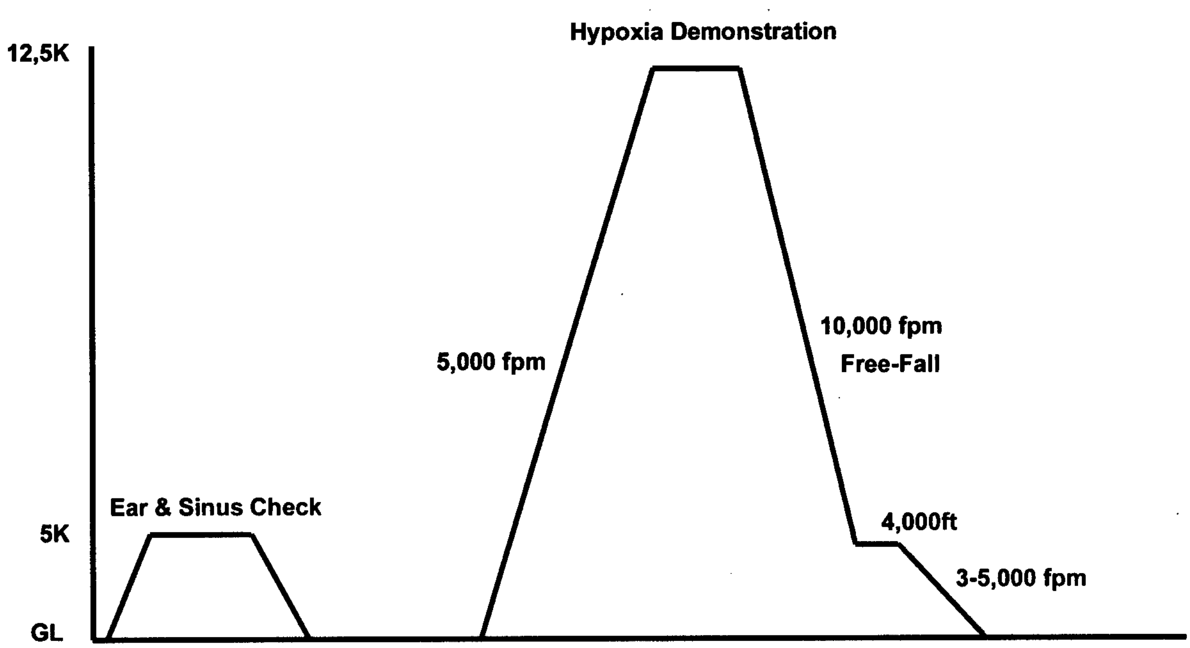


Figure 5b. Sky Hawks Profile 12,500ft

AEROSPACE PHYSIOLOGY TRAINING FOR GERMAN FEDERAL ARMED FORCES

A. Valentiner

German Air Force Institute of Aviation Medicine
Division II - Aerospace Physiology -
Steinborner Str. 43
D-01936 Koenigsbrueck, Germany

INTRODUCTION

This paper provides minutes and some of the slides of the briefing presented at the HFM Workshop in San Diego, Ca., USA, 14-16 Oct. 1998 introducing our current practice of „Aeromedical Training of Flight Personnel“ in regard to STANAG 3114.

GENERAL

The German Air Force Institute of Aviation Medicine has included all requirements of the above mentioned agreement into the training syllabus, which is also certified by USAF recognition program.
Division II provides training to personnel of all three service branches.
Continuation training interval is four years at the time of this presentation.

ACADEMIC INSTRUCTION

All topics - where applicable - are covered with specifically differing emphasis depending on type of a/c and task.
Routinely we include instruction by an aviation psychologist on various aspects of human performance and health, thereby -as a desirable side effect -lowering (still lingering) reluctance within the audience towards this profession.

PRACTICAL INSTRUCTION

- Hypobaric chamber: profiles - see following graphs -

- Hypoxia-demonstration is done twice per run. One pronounced, one moderate challenge at lower simulated altitude is offered in order to enable the student to experience differing patterns of symptoms. Before, during and after each run mental workload is induced by tasking the student with an arithmetical test, mainly for reasons of distraction.

- Capacity : max. 7 students individually seated plus 1 inside observer (paramedic)

- RD (rapid decompression) : capacity max. 2 students **without** inside observer (for aircrew in pressurized cabins only, **once,** while attending basic course) Training/demonstration **run** by PTO, FS present

- Monitoring : Heartrate - 1lead-ECG
  Ventilationrate - thermistor
  pSO_2 - pulse-oxymetry

- **Hyper**baric chamber in stand-by mode while **hypo**baric chamber in use

- Denitrogenisation : 30minutes 100% O_2 prior to each simulated altitude exposure (exc. glider course, exc. RD-runs)

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

- DCS : aprox. 5300 exposures since 1995 with **3** cases of „rule-out" diagnosis - all relieved with ground-level 100% O_2 only, no residues

- PBA : no extra training provided, but exposure to regulator-specific pressure while at pressure altitude above 28.000 ft

- Spatial disorientation : rotating chair, plus „disorientation-run" with human centrifuge for basic courses

- Ejection training: no practical demonstration device in use (anymore), academic instruction on R&S provided

- Sports : A certified training instructor offers on-the-spot advice and practice of e.g. avoidance of (lower) back pain, and related areas of interest. Emphasis is on applicable, specific physical activities, and advice on so-called no-no's (i.e. wrong lifting techniques, etc.).

DISCUSSION, SUGGESTIONS AND OUTLOOK

Our main debriefing tool is the individual printout of the applied monitoring. We feel that with its first application it has evolved into an invaluable teaching aid, since it provides additional „cues" to the individual's experience of hypoxia. Regularly we are able to show, that it is rather the rate of change in pSO_2 , not absolute levels of saturation, which induces symptoms reliably. It certainly contributes to situational awareness and supports operational safety during hypoxia demonstration itself.

A strict policy of separating training and „diagnostics" is encouraged.
The student is our, the patient is the (units) flight surgeon objective.
Medical „irregularities" seen at our installation are discussed with the student, a brief written report is sent to the student's flight surgeon.
At the moment we are unable to provide more thorough practical experience of Type I SD. Efforts are undertaken to integrate the Flight Orientation Trainer (operated by Div.III in Fuerstenfeldbruck) into a training schedule.

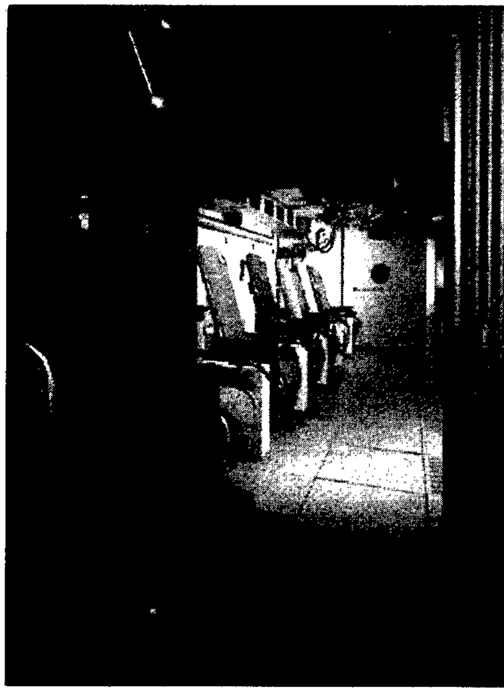
Fact finding is under way to implement new means of practical demonstration for unaided and aided (synthetic) night vision.

A new approach is suggested for teaching topics regarding Hearing:
Installation of a Sound Laboratory, which is to provide demonstration of examples for sound, noise, and the non-linear nature of human hearing perception. Furthermore to offer both (simulated) samples of identical content at different signal/noise ratios and their effects on information processing, respectively.
It will possibly enhance understanding of passive and active noise reduction means and their significance to flight safety within the audience, thereby supporting a methodically challenging area of practical teaching.

To offer good instruction and training to a demanding target group has been our goal ever.
Changes in attitude towards human factors by both our clients and within our very own Physiological Training Community require careful remodeling of training routines, especially when we focus on Continuation Courses.

STANAG 3114 offers ample opportunities to do so.

Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie

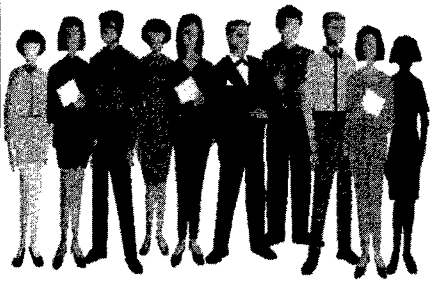


Interior of the altitude chamber

Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie

Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie

Course Categories

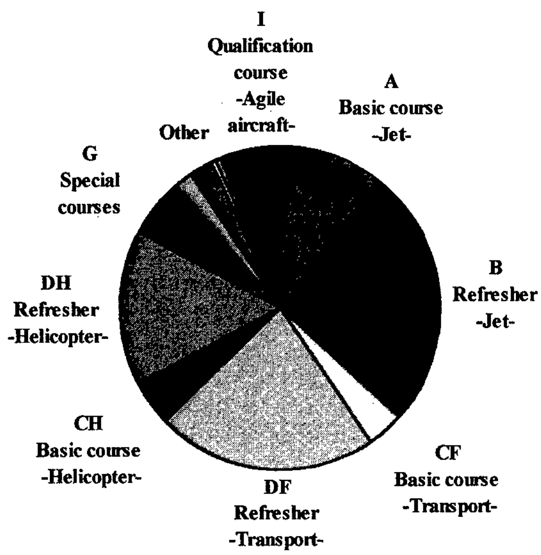


- Basic course - Jet
- Refresher - Jet
- Basic course - Transport
- Refresher - Transport
- Basic course - Helicopter
- Refresher - Helicopter
- Special courses (Glider, Special Forces etc.)
- Aviation Medicine I
- Aviation Medicine II
- Basic course - medical air transport
- Basic course flight surgeon assistants
- Basic course - Stewards
- Basic course -Austrian flying personnel
- Qualification course - High agile aircraft

Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie

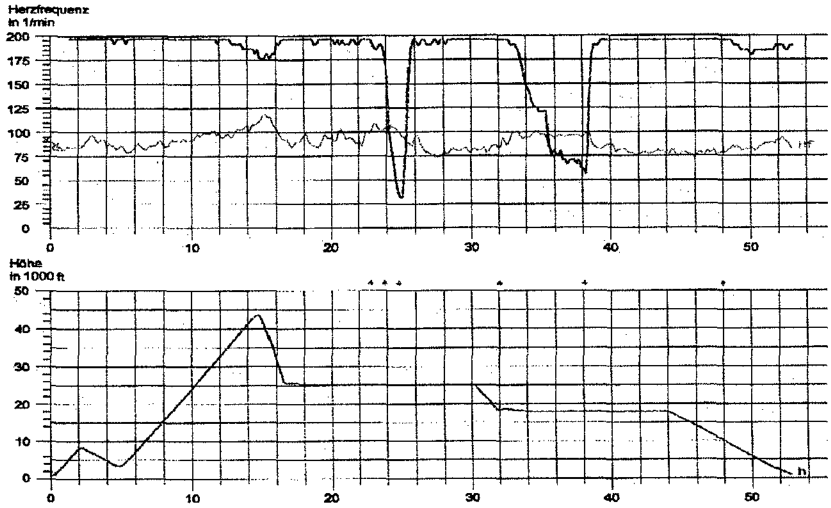
Flight Physiology Courses 1998

Σ: 155 Courses
2103 Students



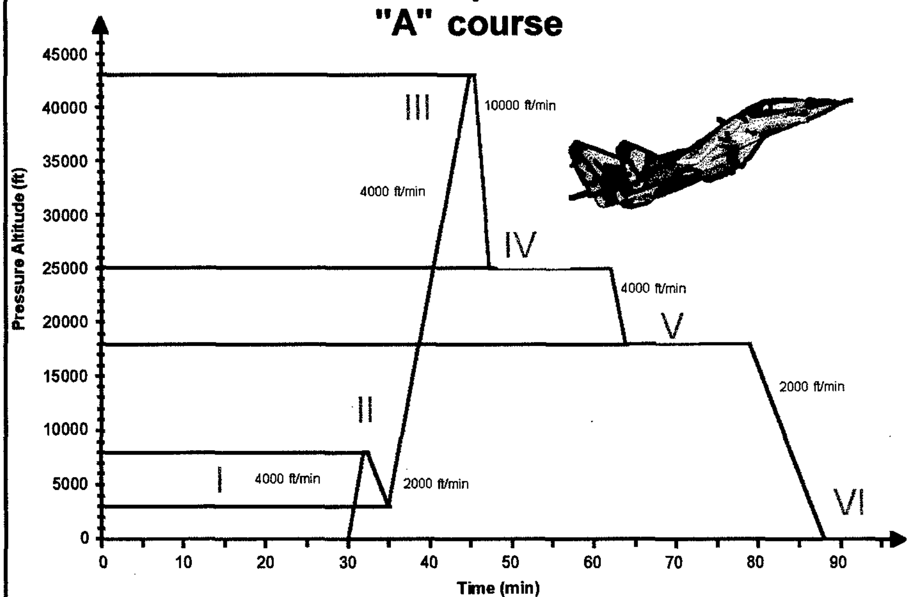
Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie

Monitoring

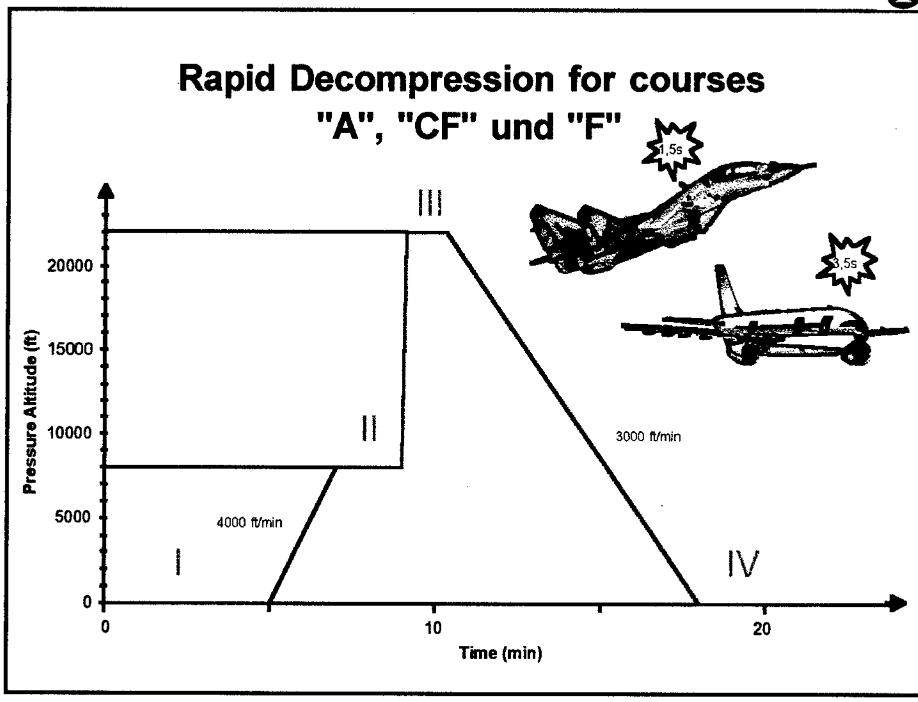


Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie

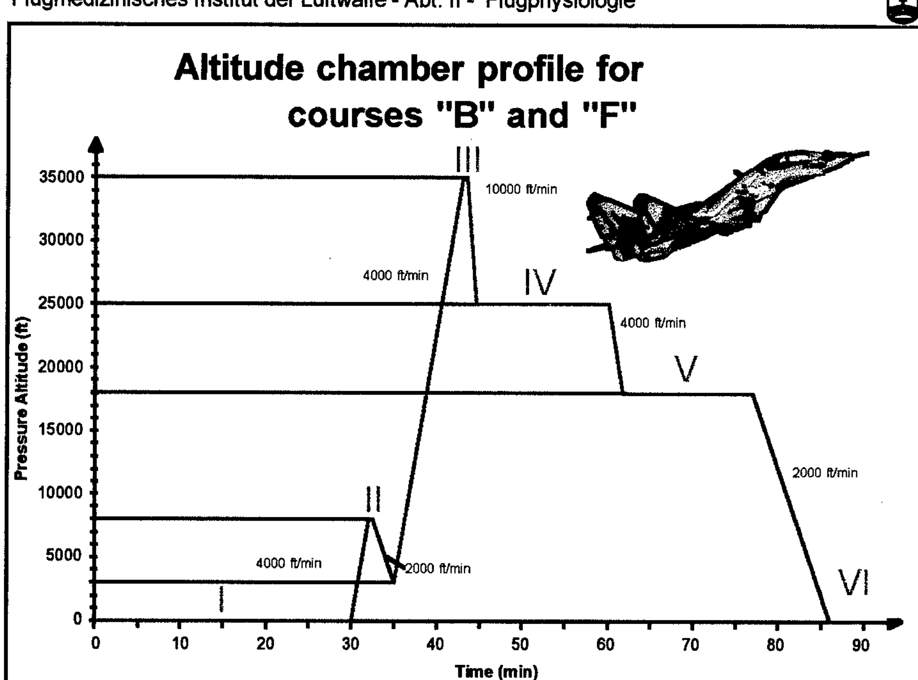
Altitude chamber profile for "A" course



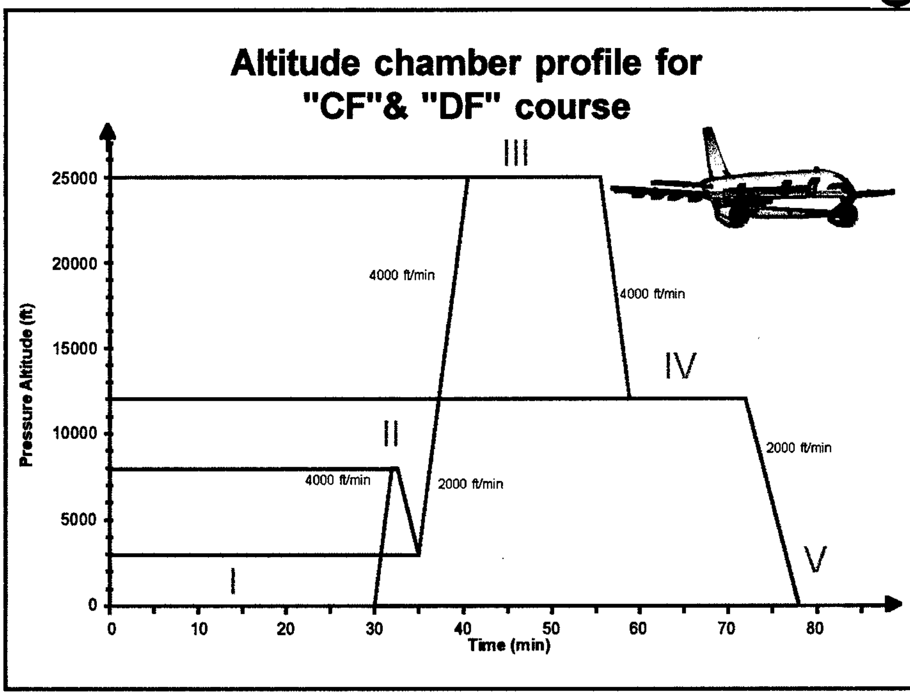
Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie



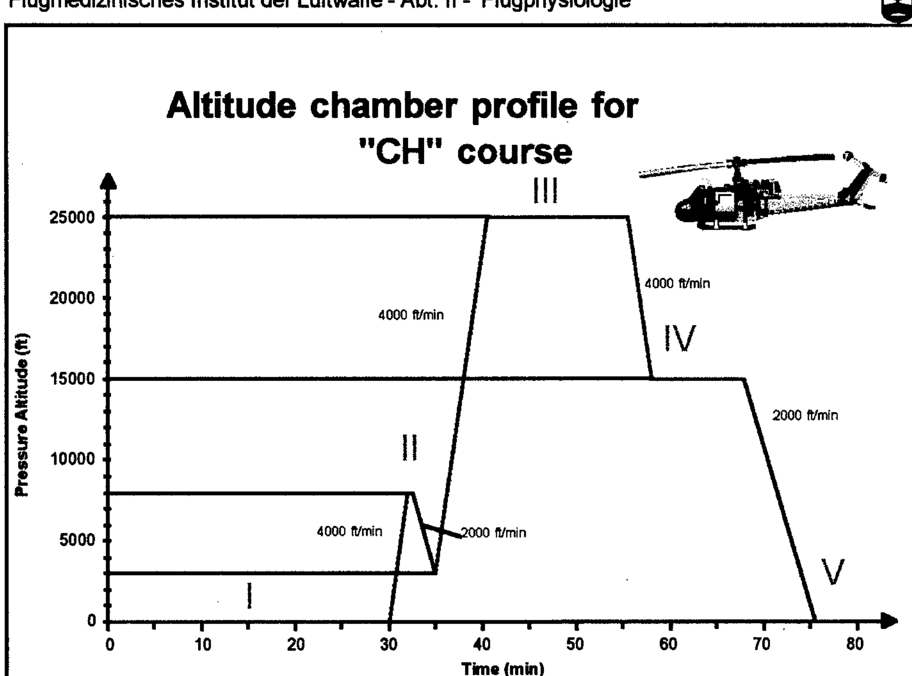
Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie

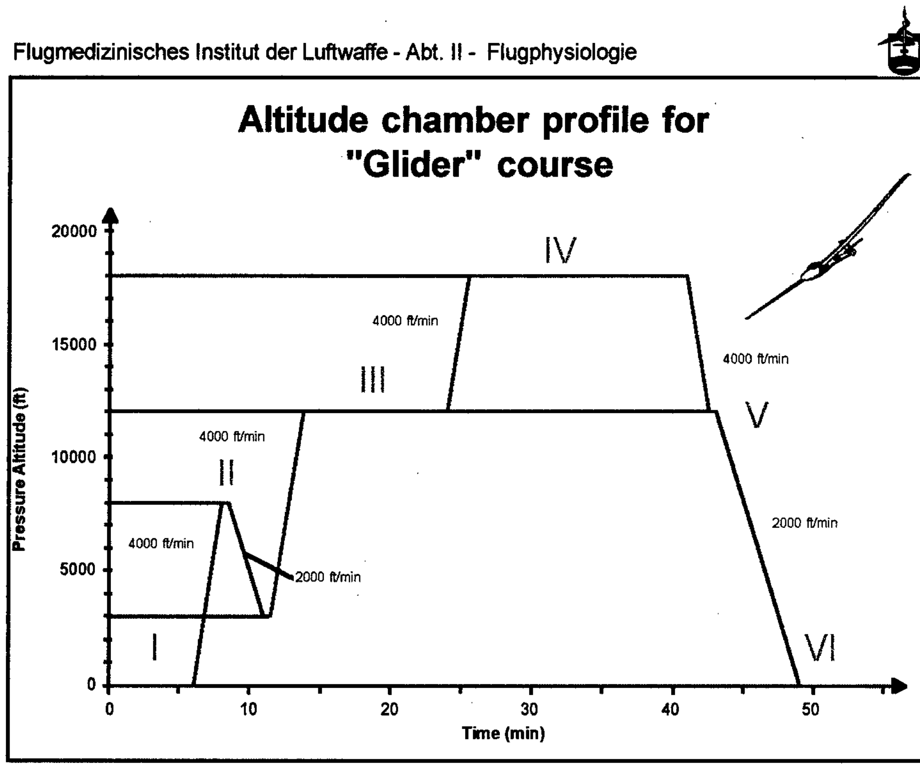


Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie

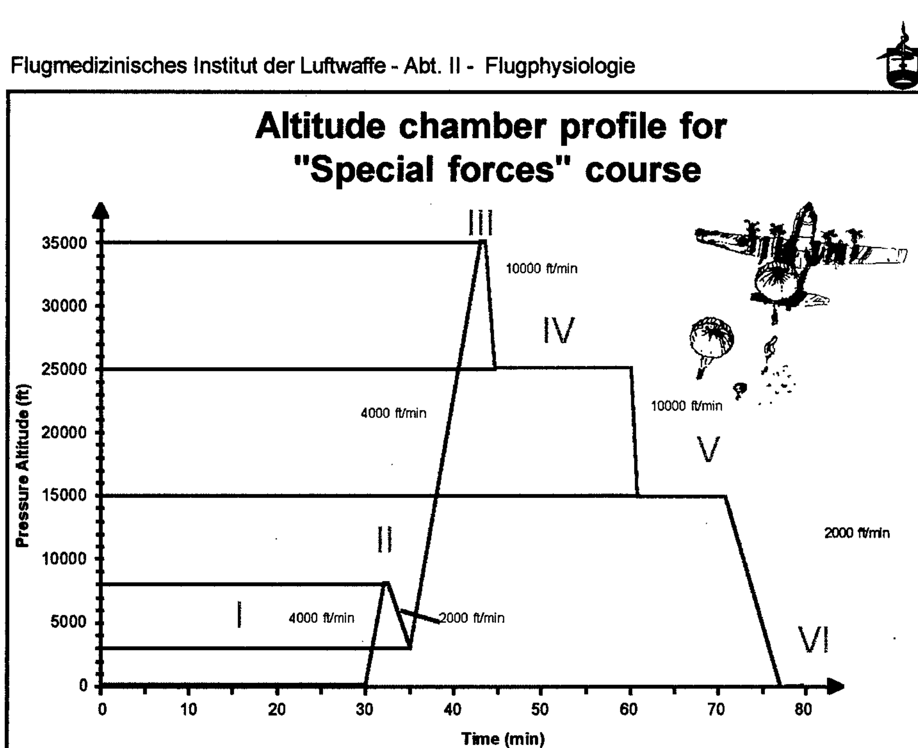


Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie





Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie
Altitude chamber profile for "Glider" course
Pressure Altitude (ft)
Time (min)
I
II
III
IV
V
VI
4000 ft/min
2000 ft/min



Flugmedizinisches Institut der Luftwaffe - Abt. II - Flugphysiologie
Altitude chamber profile for "Special forces" course
Pressure Altitude (ft)
Time (min)
I
II
III
IV
V
VI
4000 ft/min
2000 ft/min
10000 ft/min

United States Air Force (USAF) Aerospace Physiology Program

Lieutenant Colonel Jeffrey C. Sventek
AFMOA/SGOA
110 Luke Avenue, Room 405
Bolling AFB, DC 20332-7050
USA

1. SUMMARY

This paper describes the recent changes made to the USAF Aerospace Physiology training programs as presented during the 14-16 October 1998 Human Factors & Medicine Panel Workshop on Aeromedical Aspects of Aircrew Training. The USAF Aerospace Physiology training programs have changed in an effort to reduce risk and to make the training more operationally relevant for the students.

2. PREFACE

The USAF Aerospace Physiology training program provides USAF aircrew operational and aeromedical training designed to improve their performance during flight operations. Air Force Instruction (AFI) 11-403, *Aerospace Physiological Training Program*, provides the policy and guidance for this program. The USAF Aerospace Physiology training program also meets the standards established by STANAG 3114, *Aeromedical Aspects of Aircrew Training*.

The USAF Aerospace Physiology training program offers training for new aircrew members and refresher training for experienced aircrew members. Courses are designed to meet the specific needs of the student populations in an effort to provide them training which meets their operational requirements. The USAF Aerospace Physiology program is divided into seven different training courses:

- Original Training
- High Altitude Parachutist Initial Training
- Officer Cadet Initial Training
- Passenger Training
- Refresher Training
- Pressure Suit Training
- Centrifuge Training

3. ORIGINAL TRAINING

Original Aerospace Physiology training is required for all pilot and navigator trainees, all non-rated officer and enlisted aircrew members, all flight surgeons, all flight nurses, all aerospace physiologists, all aeromedical evacuation technicians, and all aerospace physiology technicians. Original training is designed for personnel who have never flown as an aircrew member and are not familiar with the physiological stresses associated with flying operations.

Original training is a two-day course, lasting approximately 16 hours. Upon successful completion of all course requirements, aircrew are certified for five years. Aircrew who completed Original training can recertify their training by completing an appropriate Aerospace Physiology Refresher course.

Original Training academic requirements include:

- Physiological Effects of Altitude
- Human Performance Issues
  - Self-imposed stress
  - Circadian rhythms
  - Situational awareness
  - Physical fitness
  - Principles of Crew Resource Management
  - Extremes of temperature
  - Diet
  - Self medication
  - Oxygen discipline
  - Fatigue
  - Alcohol
  - Smoke and fumes
  - Blood donation
  - Shock
  - Dehydration
- Oxygen Equipment
- Cabin Pressurization and Decompression
- Pressure Breathing
- Principles and Problems of Vision
- Spatial Disorientation and Other Sensory Phenomena
- Noise and Vibration
- Speed
- Acceleration
- Escape from the Aircraft
- Physiological Aspects of Ejection Seat and Parachute Training

Original training requires the successful completion of two hypobaric chamber profiles. The Type 1 hypobaric chamber flight is a simulated rapid decompression flight (Fig. 1). This profile requires an ear and sinus check from ground level to

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

5,000 feet above ground level and a return to ground level. The ear and sinus check tests the students' abilities to adequately equalize pressures within the middle ear and sinus cavities. Any students experiencing difficulties during the ear and sinus check are removed for evaluation. All students then undergo a rapid decompression from 500 feet above ground level (AGL) to an altitude which will generate a total pressure change of 4.5 pounds per square inch (psi) in one to two seconds. Students are required to recognize the occurrence of the rapid decompression and don their oxygen equipment to prevent the possibility of hypoxia just as they would in an aircraft.

TYPE 1 HYPOBARIC CHAMBER FLIGHT (RAPID DECOMPRESSION)

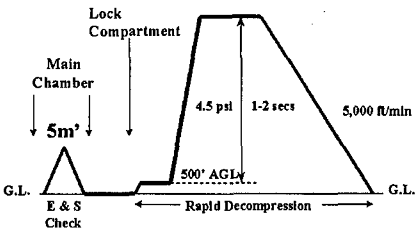


Figure 1

Original training students must also successfully complete a Type 2 hypobaric chamber flight (Fig. 2). This chamber flight is designed to provide students the opportunity to experience high altitude (35,000 feet), pressure breathing, hypoxia, and a demonstration of the effects of subtle hypoxia on visual acuity. Students also have the opportunity to practice the proper use of oxygen equipment. Because students and inside instructors are exposed to unpressurized altitudes above 18,000 feet, all personnel are required to complete 30 minutes of denitrogenation prior to ascent to the peak altitude of 35,000 feet. All ascent and descent rates for this profile are 5,000 feet per minute (fpm).

TYPE 2 HYPOBARIC CHAMBER FLIGHT

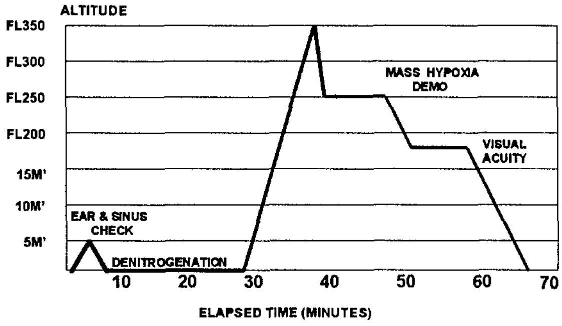


Figure 2

4. HIGH ALTITUDE PARACHUTIST INITIAL TRAINING

The High Altitude Parachutist (HAP) Initial training is designed for parachutists who are required to make parachute drops from above 10,000 feet Mean Sea Level (MSL). This course of instruction focuses on the specific physiological problems associated with high altitude parachute operations. The HAP Initial training is a one day course, incorporating approximately 8 hours of lessons. Upon successful completion of the training requirements, parachutists are certified for five years. Parachutists who completed the HAP Initial training can recertify their training by completing an appropriate Aerospace Physiology Refresher course.

HAP Initial training requirements include:

- Physiological Effects of Altitude
- Human Performance Issues
- Oxygen Equipment
- Pressure Breathing
- Principles and Problems of Vision
- Noise and Vibration
- Escape from the Aircraft

HAP Initial training requires the successful completion of the Type 3 hypobaric chamber flight (Fig. 3). This chamber flight provides HAP Initial students the opportunity to experience high altitude (35,000 feet), pressure breathing, pressure changes associated with free fall (35,000 feet to 8,000 feet), hypoxia, and a demonstration of the effects of subtle hypoxia on visual acuity. Students also have the opportunity to practice the proper use of aircraft and parachuting oxygen equipment. As was the case with the Type 2 chamber flight, students and instructors must complete 30 minutes of denitrogenation prior to ascent to 35,000 feet in an effort to reduce the risks of decompression sickness.

All ascent and descent rates for this chamber flight are 5,000 fpm except for the freefall portion from 35,000 feet to 8,000 feet where a descent rate of 10,000-12,000 fpm is used.

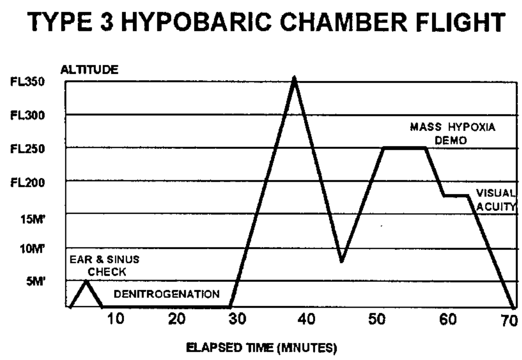


Figure 3

5. OFFICER CADET INITIAL TRAINING

Officer Cadet Initial (OCI) training is offered for all USAF Academy and Air Force Reserve Officer Training (AFROTC) cadets who have the potential for fly in USAF aircraft above 18,000 feet MSL. This training provides these cadets with limited insight into the physical and physiological requirements to fly as a passenger in all USAF aircraft above 18,000 feet MSL. Upon successful completion of the OCI training requirements, cadets are certified for three years. However, cadets cannot recertify this training by completing an Aerospace Physiology Refresher course. OCI training is only designed to satisfy Aerospace Physiology training requirements for cadets during their college years. OCI training is a one day course and includes approximately 8 hours of academic and chamber training.

OCI academic requirements include:

- Physiological Effects of Altitude
- Human Performance Issues
- Oxygen Equipment
- Cabin Pressurization and Decompression
- Pressure Breathing
- Principles and Problems of Vision
- Spatial Disorientation and Other Sensory Phenomena
- Noise and Vibration
- Acceleration
- Physiological Aspects of Ejection Seat and Parachute Training

OCI training requires the successful completion of a Type 4 hypobaric chamber flight (Fig. 4). This profile provides cadets with the opportunity to experience a rapid decompression, high altitude (25,000 feet), hypoxia, pressure breathing, and the effects of subtle hypoxia on visual acuity. Students are also provided the opportunity to practice using various types of oxygen equipment they might be required to use in USAF aircraft. As was the case with the Type 2 and Type 3 chamber flights, students and instructors must complete 30 minutes of denitrogenation prior to ascent to 25,000 feet in an effort to reduce the risks of decompression sickness. All ascent and descent rates for this chamber flight are 5,000 fpm except for the rapid decompression portion from 8,000 feet to 25,000 feet where an ascent rate of 10,000-12,000 fpm is used.

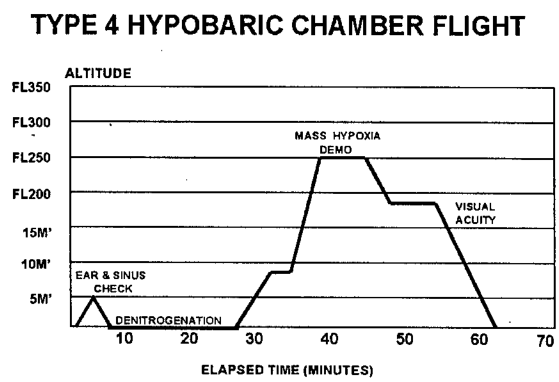


Figure 4

6. PASSENGER TRAINING

Passenger training is a course designed for personnel scheduled to fly above 18,000 feet MSL as a passenger in non-cargo or non-passenger USAF aircraft. This course familiarizes passenger students with potential aeromedical problems which may occur during their ride. Upon completion of the Passenger training requirements, students are certified for one year. Passenger trainees cannot recertify this training by completing an Aerospace Physiology Refresher course. Passenger training is only designed to satisfy Aerospace Physiology training requirements for personnel scheduled for orientation or familiarization flights during a specific period of time. Passenger training is a one day course and includes approximately 6 hours of academic and chamber training.

Passenger training academic requirements include:

- Physiological Effects of Altitude
- Human Performance
- Oxygen Equipment

- Cabin Pressurization and Decompression
- Pressure Breathing
- Noise and Vibration
- Acceleration (fighter/trainers only)
- Physiological Aspects of Ejection Seat and Parachute Training

Passenger training requires the successful completion of a Type 4 hypobaric chamber flight (Fig. 4). This profiles provides students with the opportunity to experience a rapid decompression, high altitude (25,000 feet), hypoxia, pressure breathing, and the effects of subtle hypoxia on visual acuity. Students are also provided the opportunity to practice using various types of oxygen equipment they might be required to use in USAF aircraft. As was the case with the Type 2 and Type 3 chamber flights, students and instructors must complete 30 minutes of denitrogenation prior to ascent to 25,000 feet in an effort to reduce the risks of decompression sickness. All ascent and descent rates for this chamber flight are 5,000 fpm except for the rapid decompression portion from 8,000 feet to 25,000 feet where an ascent rate of 10,000-12,000 fpm is used.

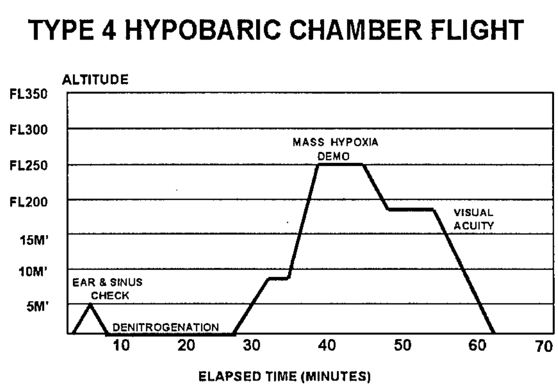


Figure 5

6. REFRESHER TRAINING

Refresher training is designed to recertify training for Original, HAP, and Refresher students. Aircrew are scheduled into one of three separate Refresher courses based on the type of aircraft they routinely operate. Trainer, Attack, Reconnaissance, and Fighter (TARF) aircrew participate in a Refresher course designed to address TARF specific aeromedical issues. Tanker, Transport, Bomber (TTB) aircrew participate in a Refresher course designed to address TTB specific aeromedical issues. Helicopter (HELO) aircrew participate in a Refresher course designed to address HELO specific aeromedical issues. Upon successful completion of the Refresher training requirements, aircrew are recertified for five years. Aircrew with more than 20 years of flying experience and who have also completed initial training and two or more Refresher chamber flights, must complete Refresher academics but participation in the hypobaric chamber flight is their option. Refresher training is a one day course and includes approximately five or more hours.

Refresher training academics reviews aeromedical training issues which could impact on aircrew performance in the aircraft they are assigned. All three of the different Refresher courses divides the academic material into five categories:

- Human Performance
  - Situational Awareness
  - Attention Management
  - Cognitive Performance
- Perception and Spatial Disorientation
- Mission-Imposed Threats to Human Performance
- Self-Imposed Threats to Human Performance
- Altitude-Imposed Threats to Human Performance

Refresher training requires the successful completion of a Type 4 hypobaric chamber flight (Fig. 4). This profiles provides aircrew with the opportunity to experience a rapid decompression, high altitude (25,000 feet), hypoxia, pressure breathing, and the effects of subtle hypoxia on visual acuity. Aircrew are also provided the opportunity to practice using various types of oxygen equipment they are required to use in their aircraft. As was the case with the Type 2 and Type 3 chamber flights, aircrew and instructors must complete 30 minutes of denitrogenation prior to ascent to 25,000 feet in an effort to reduce the risks of decompression sickness. All ascent and descent rates for this chamber flight are 5,000 fpm except for the rapid decompression portion from 8,000 feet to 25,000 feet where an ascent rate of 10,000-12,000 fpm is used.

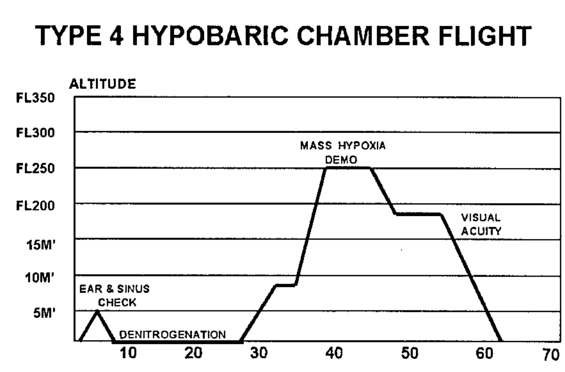


Figure 6

7. CERTIFICATION OF INTERNATIONAL PROGRAMS

The USAF also evaluates and certifies Aerospace Physiology and Centrifuge training programs offered by international allied nations. These evaluations and the subsequent certification extends beyond the STANAG 3114 signatories. Any aircrew from countries whose training programs have been evaluated and certified as acceptable to the USAF are not required any additional aeromedical training prior to flying in USAF aircraft. Aircrew from countries whose aeromedical training programs are not certified as acceptable to the USAF must complete the appropriate physiology or centrifuge training prior to their first flight in USAF aircraft.

The following countries offer Aerospace Physiology training programs acceptable to the USAF:

- Australia
- Canada
- Denmark
- Germany
- Greece
- Japan
- Jordan
- Korea
- Netherlands
- Norway
- Pakistan
- Philippines
- Portugal
- Saudi Arabia
- Singapore
- Taiwan
- Thailand
- Turkey
- United Kingdom

8. CIVILIAN TRAINING

Civilian personnel can be trained in USAF Aerospace Physiology facilities if they are authorized by the local Wing Commander. If approved for training, civilian personnel must complete either the Original, Passenger, or Refresher training courses. All civilians must be at least 18 years of age to qualify for training consideration.

Civilians not approved for USAF Aerospace Physiology training can complete similar training through the Federal Aviation Administration (FAA) Aerospace Physiology training program. The FAA owns only one altitude chamber and the number of applicants for this training far exceeds their training capacity, so the FAA and the USAF have a formal agreement which authorizes the USAF Aerospace Physiology training facilities to provide FAA Aerospace Physiology training at the USAF facilities. This agreement has been in existence for over 20 years and the USAF has provided over 20,000 students with FAA Aerospace Physiology training during that time.

9. PRESSURE SUIT TRAINING

Pressure suit training is required for all personnel who routinely fly above 50,000 feet MSL. This training is provided by the 9th Physiological Support Squadron at Beale AFB, CA. Original, Passenger, and Refresher pressure suit training courses are offered. Those aircrew who complete the Original or Refresher pressure suit courses are certified for three years. Passenger pressure suit training is certified for only 90 days.

The academics for these courses focus on pressure suit operations and the dangers of flying above 50,000 feet MSL. Special hypobaric chamber profiles are used to build confidence in the students' minds that their life support equipment will protect them against the physiological dangers associated with loss of pressurization above 50,000 feet MSL.

10. CENTRIFUGE TRAINING

Centrifuge training is governed by AFI 11-404, *Centrifuge Training for High-G Aircrew*. This guidance requires all personnel who fly high performance aircraft to complete centrifuge training. Original and Refresher training is offered. Upon successful completion of the required academics and centrifuge rides, aircrew are certified indefinitely unless a break of more than 3 years from flying high performance aircraft occurs.

11. REENGINEERING PROPOSAL FOR USAF AEROSPACE PHYSIOLOGY

The USAF Chief of Staff (CSAF) approved a proposal to completely reengineer the Aerospace Physiology career field and the underlying training philosophy. For nearly 50 years, the USAF Aerospace Physiology training philosophy has been to train aircrew at the altitude chamber locations. The new proposal calls for reducing the number of altitude chamber training sites from 19 to 14 over a five year period, extending the chamber exposure requirement from three years to five years, and deploying two person Human Performance Training Teams (HPTT) to all USAF active wings without Aerospace Physiology facilities assigned. Refresher academics would be provided by the local HPTT in a just-in-time training philosophy. This philosophy requires the academic lessons previously provided at the altitude chamber once every three years to be incorporated into the continuation training timeline for all aircrew. The training would be scheduled to be provided just before it would be needed by the aircrew. For example, if a fighter unit is scheduled to begin night flying over the next two weeks, the HPTT would meet with the aircrew and provide a series of lessons on aeromedical aspects of night operations. Spatial disorientation lessons would be provided in conjunction with the instrument check ride cycle. Lessons on situational awareness would coincide with Cockpit/Crew Resource Management (CRM) training.

The altitude chamber requirement was extended from a three year requirement to a five year requirement on 1 October 1998. Every aircrew member who completed Aerospace Physiology training after this date was certified for five years. Over the next three years, all USAF aircrew will have been trained and certified for five years. A significant reduction in Refresher training will occur for the following two years. This lull in training occurs at a time when we will be closing five chamber units and deploying HPTTs to the wings.

The map below (Fig. 7) shows the 18 Aerospace Physiology chamber locations in the continental United States (CONUS).

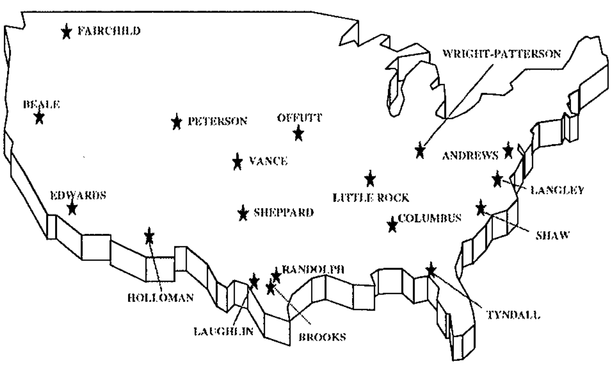


Figure 7

Figure 8 shows the impact of closing five CONUS Aerospace Physiology chamber locations.

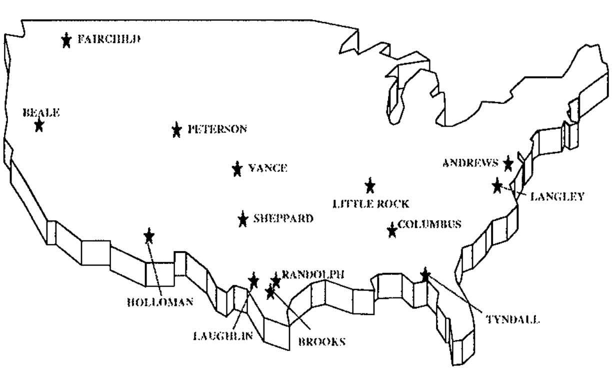


Figure 8

By closing five facilities and extending the chamber requirement from three years to five years, the remaining 14 chamber facilities will absorb the training load and provide more efficient training services for the USAF. In addition, closing these five facilities will reduce manpower requirements for the Aerospace Physiology program and save operations and maintenance money for the USAF.

Some of the manpower savings will be reinvested in the form of HPTTs. These two-person teams will have one Aerospace Physiology officer and one Aerospace Physiology technician assigned to the Aerospace Medicine Squadrons at active USAF wings without physiology expertise. Figure 9 shows the locations of the 14 remaining chamber locations and the CONUS locations for the HPTTs.

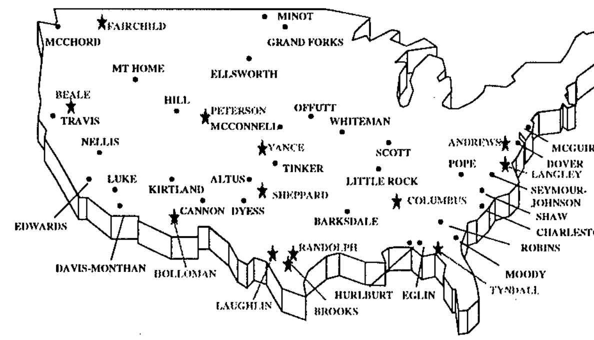


Figure 9

The HPTTs will team with flight/missile medicine, wing safety, wing life support, wing health promotion, wing disaster preparedness, medical readiness, and other local agencies to orchestrate all wing human performance training activities.

The Pacific Air Forces (PACAF) will retain the one altitude chamber facility at Kadena AB, Japan, but will also receive seven HPTTs. Figure 10 shows the PACAF locations.

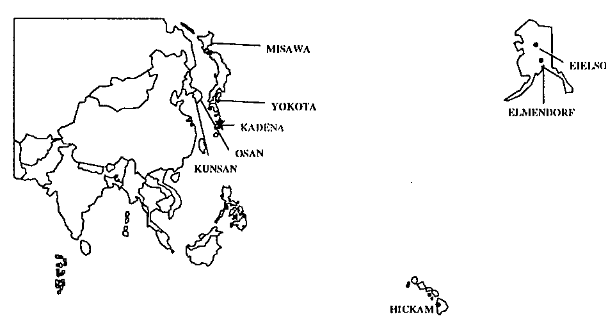


Figure 10

United States Air Forces Europe (USAFE) will stand up five HPTTs, but the USAF does not maintain any altitude chamber training facilities in the theater. Instead, USAF has training agreements with the Royal Netherlands Aerospace Physiology training facility at Soesterberg, NL, and the Royal Air Force Aerospace Physiology training facility at RAF Henlow, UK. USAF Aerospace Physiology experts provide the academic training to USAFE aircrew and chamber flights are provided through the international agreements. Figure 11 shows the locations of the British and Dutch chamber locations as well as the locations of the HPTTs.

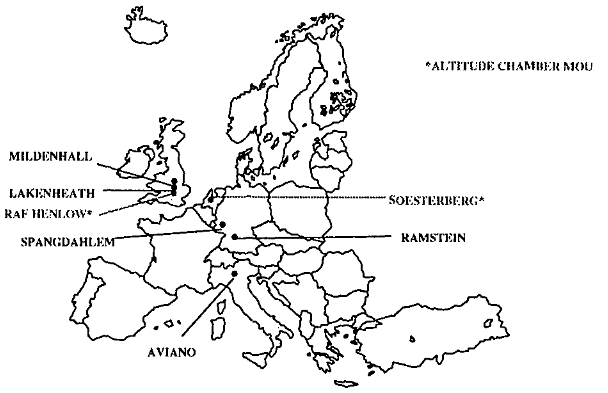


Figure 11

Overall, the reengineering plan for USAF Aerospace Physiology will close five chamber units over a 4-5 year period, assign two-person HPTTs to every USAF flying wing, provide aeromedical training in a just-in-time philosophy at the local wing, and extend the chamber exposure requirement from every three years to every five years. This initiative consolidates human performance, physiology, life support, safety, and nuclear/biological/chemical training for all wing personnel, reducing training repetition and redundancies. The plan will save aircrew training and the USAF manpower and money. Training will be expanded from just aircrew to non-aircrew personnel as well. The goal of this reengineering effort is to enhance the human performance of all USAF personnel through expanded and improved human performance and physiology training methods.

AIRCREW AEROMEDICAL TRAINING
HELLENIC AIR FORCE PROGRAM

Cpt Odysseas Paxinos MD, BrGen Elias Chimonas MD

Hellenic Center of Aviation Medicine
251 Hellenic Airforce Hospital
3 P. Kanellopoulou Str. - Holargos
Athens - Greece

1. SUMMARY

Aviation physiology training and medical certification for both military and civil aircrews is carried out in Greece in the Center of Aviation Medicine (KAI). Military aircrew training is carried out with reference to STANAG 3114 and includes altitude chamber flights and spatial disorientation trainer rides. Centrifuge training for fighter pilots is provided under contract abroad. Refresher lecture courses are provided annually and practical training every 3 years. The Center is currently being upgraded to meet future needs.

2. INTRODUCTION

Aviation medicine and physiology training for both military and civil aircrews is carried out in Greece at the Hellenic Center of Aviation Medicine. The Center was founded in 1952 as Aircrew Physiological Training Unit to become Center of Aviation Medicine (KAI) in 1972. The Center which is since 1972 based in the 251 Hellenic Air Force Hospital complex is the only organization responsible for initial medical selection as well as examination and certification of both civil and military aircrews. The Center also provides training in aerospace medicine for flight surgeons and flight nurses and aerospace physiology for military aircrews including hypobaric chamber flights and disorientation trainer rides. The Center is currently being upgraded to meet the future challenges in aircrew training and selection.

3. AEROMEDICAL TRAINING PROGRAMS

All aircrew-training courses are carried out with reference to Stanag 3114. The courses are specific to the aims and objectives of the addressed group and constructed to be as varied and as interesting as possible. Most of the courses consist of lectures and discussion groups. Teaching material includes pamphlets, handouts, videotapes, slides and computer presentations. Practical training (altitude chamber flights, disorientation trainer rides, survival, jet aircraft orientation flights) is given in the initial courses. Continuation practical training is given to active aircrews every 3 years.

3.1. Initial Aviation Medicine Training of Aircrews

The initial aviation medicine training is given to pilots in the Airforce Academy and consists of 60 hours total academic instruction and practical exercises. The course follows the syllabus lectures as described in Table 1.

Each Cadet undergoes an exposure to a simulated altitude of 30.000 ft in the hypobaric chamber of the Center of Aviation Medicine. Each Cadet gets personal experience of the effects of hypoxia in this altitude. Decompression sickness is avoided by breathing 100% oxygen for 30 minutes. For safety reasons the hypoxia demonstration is done in pairs. This profile is named III and is described in table 2. Recently a visual acuity demonstration has been added (dotted line).

Table 1. *Lecture syllabus of Initial Aviation Medicine Course (Cadets)*

- Aims. Definitions. Scope
- The Atmosphere. Gas laws
- Respiration and circulation
- Hypoxia - hyperventilation
- Gas expansion - physiologic effects
- Decompression sickness
- Oxygen equipment - cabin pressurization
- Sensory and nervous system
- Noise and vibration
- Vision and flight
- Spatial disorientation
- Motion sickness
- Stress – fear of flying
- Human factors and aircraft accidents
- Circadian rhythms – sleep disturbances
- Acceleration environment – definitions – physiology
- Sustained G acceleration – protection
- Escape
- Survival (sea - land)
- Thermal stress
- First aid
- Physical fitness
- Imposed stresses - toxic substances
- Pilot medical certification

Rapid decompression demonstration gives the Cadets a personal experience of a pressure change from 8.000 ft to 30.000 ft in 3 sec.

Vestibular stimulation demonstration using a disorientation trainer is supplementing the academic instruction of spatial disorientation.

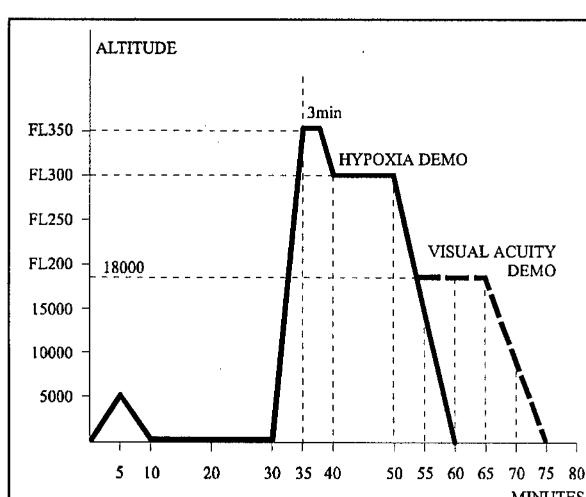


Table 2. *Type III hypobaric chamber flight (dotted line represents recent addition of visual acuity demo).*

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

No ejection trainer is available in the Hellenic Air Force, so Cadets receive only academic and ground egress training.

Non pilot aircrew members that come from other military schools (navigators, flying engineers) follow the same syllabus as the Cadets but of 30 hours total duration. They receive the same practical initial training.

3.2. Continuation Aviation Medicine Training of Aircrews

A continuation-training course is scheduled for aircrews every 3 years. The course syllabus is related to the special type of aircraft that the aircrew is operating. Major interest is given in safety and survival as well as life support systems of the aircraft. The course is of one-day duration and the syllabus is a quick revue of the initial training syllabus.

Practical instruction consists of a simulated altitude flight with hypoxia demonstration which is at 20.000 ft for aircrew members above 45 years of age (type II) and 30.000 ft for younger persons (type I) (table 3).

Disorientation trainer rides are given every year during the annual medical examination.

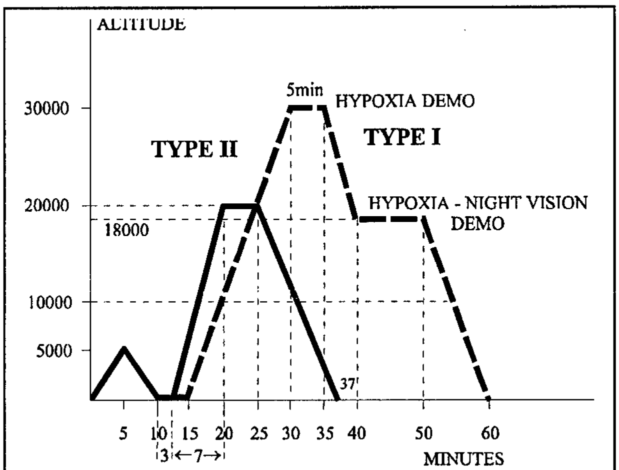


Table 3. *Type I and type II chamber flights (continuation training)*

3.2.1. Other Continuation Training Courses

The Center of Aviation Medicine and the Office of Surgeon General provide the local flight surgeons with instructional material (slides and pamphlets) so they can organize a six hour refresher course every year in the individual bases. The syllabus of these courses depends on the aircraft flown and the mission of the base.

One-day Aviation Medicine lectures are also included in other courses syllabus as the Flight Safety Officers Seminar, and the War Academy.

Pilots that will fly the M-2000 or F-16 C/D are given a formal centrifuge training in Sösterberg (Holland). Prior to this practical training they receive a 6 hours lecture and group discussion course on Acceleration Physiology and Protective Measures.

4. OTHER AVIATION MEDICINE COURSES

The Center of Aviation Medicine (KAI) organizes and runs every year the School of Aerospace Medicine for young Flight Surgeons, which is of 3 months duration. The syllabus is very extended, based in the experience of similar NATO schools. The school provides practical training in water survival, hypobaric chamber flights, disorientation trainer rides and finally orientation flights with jet trainers (T-37B, T-2). The Center also runs every year the Flight Nurse Course, which is of 40 days duration and includes practical training, as well as actual medevac missions with the H-205B and C-130H aircrafts.

5. REMARKS

The Hellenic Center of Aviation Medicine is currently being renovated and upgraded to comply with the future aviation medicine challenges. One of the current projects is the upgrading of the existing altitude chamber and the replacement of the disorientation trainer. Heavily loaded with the selection and medical certification of both civil and military aircrew the Center was still able to train enough Flight Surgeons for the needs of Army and Navy Aviation, which now run their own Physiology Training Programs.

Royal Air Force High Altitude Physiological Training

Wing Commander DP Gradwell BSc, PhD.
DAvMed MRAeS
RAF Center of Aviation Medicine
Henlow, Beds SG16 6DN
United Kingdom

Introduction

The Royal Air Force continues to operate aircraft at altitudes in excess of 50,000feet. To provide short-term protection against hypoxia in the event of loss of cabin pressure the aircrew are trained in the technique of positive pressure breathing and the use of counter-pressure garments at altitude.

Although the life support systems of many military fast jet aircraft provide pressure breathing it is commonly limited to a pressure of 30mmHg above ambient. The use of breathing pressures higher than 30mmHg requires the use of counter-pressure assemblies to reduce the adverse physiological side effects of pressure breathing. The aim of the high altitude aviation medicine training is to familiarise the aircrew with the personal equipment they must wear, the operation of the aircraft's oxygen systems in the event of a decompression at high altitude, to become competent in the performance of the correct pressure breathing technique and finally to undergoing a rapid decompression from 25,000ft to 56,000ft in three seconds in a hypobaric chamber.

Training Team

The team of staff required to carry out the aircrew training is headed by a Consultant in Aviation Medicine with extensive experience of high altitude decompressions and the use of positive pressure breathing. He is responsible for the conduct of the whole exercise including the fitting of the partial pressure counter-pressure assembly worn by the aircrew, their training in pressure breathing and the preparation and performance of the decompression outlined above. A second medical officer experience in such procedures is also required to act as the medical monitor for the decompression itself, observing and reporting the physiological indices detailed below.

Technical staff qualified and experienced in the fitting of partial pressure garments and the checking of its function on inflation are necessary to assist the medical officers. Further staff are necessary to act as (a) pressure chamber operators (two), (b) to conduct the essential physiological instrumentation of the aircrew trainee, both whilst practising pressure breathing at ground level and during the decompression in the hypobaric chamber, and (c) as safety officers at an intermediate altitude in the hypobaric chamber during the decompression itself.

Partial pressure garment assembly

The current standard RAF counter-pressure assembly of partial pressure garments consists of a jerkin and anti-G trousers. The jerkin covers the torso in a one-piece circumferential garment that contains a rubber bladder in communication with the breathing gas supply hose. When the breathing pressure delivered from the oxygen demand regulator rises on the initiation of pressure breathing the pressure within the bladder rises in parallel. By this means counter-pressure equal to the breathing pressure is applied to the whole of the chest and abdomen, including the hernial orifices. In addition to the jerkin the aircrew wear conventional anti-G trousers, but these too are inflated from the breathing gas supply, not through an anti-G valve. This system ensures that when pressure breathing is carried out counter-pressure is applied to the legs as well as the torso, helping to restore venous return and reduce the circulatory stress of the procedure.

Training methods

When receiving this type of training, usually conducted over a two-day period, the aircrew

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

attend in pairs. On arrival the aircrew are given a tutorial by the senior medical officer in which the principles of short duration protection against hypoxia by use of pressure breathing is explained and the operation of the aircraft life support systems revised. They are briefed on the appropriate breathing cycle to adopt during pressure breathing. The fit of the aircrews' mask, helmet and partial pressure assembly is checked and the garments pressure checked for any leaks, which could degrade the degree of protection afforded. The aircrew equipment assembly (AEA) is also checked to ensure that all pyrotechnic devices have been removed for this training exercise.

The aircrew are given a short medical examination, including aviation medical history, auscultation of the heart and lungs, determination of pulse and blood pressure, and direct observation of the tympanic membranes. Thereafter for the course of pressure breathing training and during the decompression on the following day the aircrews' ECG is monitored through composite chest electrodes.

In turn the aircrew are seated at a pressure breathing training bench and their personal experience of pressure breathing and the training in the necessary breathing pattern begun. The seat itself is equipped with a five point harness and is capable of being immediately tilted back into a horizontal position in the event that a trainee develops syncope, a known potential side-effect of pressure breathing, especially in the inexperienced.

RAF aircrew are trained to adopt a breathing pattern during pressure breathing of a slow, but continuous respiratory cycle. That is, inspiration over five seconds is followed by exhalation over the next five seconds, with the cycle repeated continuously whilst the mask pressure is elevated. Pressure breathing training is carried out with the individual breathing air delivered via the training bench at the desired added pressure. Throughout all such exercises the subject is monitored closely and the following are recorded: ECG, heart rate, blood pressure and mask tube pressure (breathing pressure). A closed-circuit video system is used as a teaching aid and as a visual record of the subject's performance whilst pressure breathing. Further, the inspiratory and expiratory breathing gas flows are measured by use of Fleisch pneumotachographs. The resulting flow pattern is displayed with an idealised sinusoidal flow trace on a screen in front of the pressure breathing subject. This allows the individual to modify their own breathing cycle to help achieve the desired one.

The initiation of pressure breathing is preceded by a countdown from "5" to "Now", to ensure the individual is in an appropriate part of the respiratory cycle as the pressure rises. Although, clearly, this would not occur in the air during an actual aircraft decompression, nor would there then be a risk of the individual holding their breath in anticipation of the event. As pressure breathing is initiated the subject rolls the mask toggle down to increase the tension in the mask suspension harness and thereby apply the mask more firmly to the face, to reduce the likelihood of mask leaks whilst the mask cavity pressure is high. A progressive increase in the applied breathing pressure is delivered, as the subjects become competent in the technique. With periods of two minutes at each pressure subjects commence the exercises at a breathing pressure of 20mmHg, followed by 30 and 40mmHg. A rest period of 10 to 30 minutes (increasing in step with the breathing pressure) is required between exercises to reduce the effects of blood pooling and the attendant risk of syncope. When there are two subjects being trained it is convenient to change subjects and continue the exercise with the rested subject while the first one uses the opportunity to take a gentle walk, thereby aiding the restoration of normal haemiostatic conditions. Following satisfactory completion of each exercise the breathing pressure is increased until the subject is able to pressure breathe at 70mmHg for two minutes and, on a separate occasion, breathe at a positive pressure of 70mmHg for 30 seconds followed by a decay in pressure to 0mmHg over a period of 95 seconds. The last training exercise therefore simulates the pressure breathing profile that will occur during the rapid decompression to 56,000ft.

<u>Rapid decompression</u>

On the day following their pressure breathing training the aircrew present for rapid decompression in a hypobaric chamber. A short medical examination is carried out and the subsequent procedures to be adopted briefed again. If passed fit for decompression the subject dons

ECG leads and then dresses in his full AEA, including the partial pressure garments described above. A check of the fit of his oxygen mask is carried out; thereafter he does not drop his mask again until instructed to do so in the chamber during the final stages of his descent from altitude.

A minimum of 30 minutes of denitrogenation on 100% oxygen is then undertaken, with a small degree of safety pressure present in the breathing system to ensure that any gaseous leaks are outbound. Two way communication is maintained between the subject and at least one member of the training team.

The hypobaric chamber will have been previously prepared with suitable physical and physiological instrumentation installed. The signals are displayed to members of the team and recorded on analogue paper record and digital audio tape (DAT). The exact decompression profile of the RD is carried out, unmanned, in the chamber before other procedures begin. It is essential also that an adjacent hyperbaric facility is also tested at the start of the day of the decompression to demonstrate the capability of achieving an immediate compression to depth if required for therapeutic purposes.

The monitoring includes, chamber altitude, mask tube pressure (breathing pressure), ECG, heart rate and SaO_2. Blood pressure can also be monitored but to limit the number of leads and encumbrances on the aircrew subject for this type of training decompression, BP is usually omitted. Two way communication between all members of the training team is checked, although during the decompression only the senior medical officer talks to the subject, so to avoid potential confusion to the individual undergoing training. However, the senior medical officer will request from others details of the essential physiological parameters at intervals during the procedure.

At the end of the denitrogenation period the subject is transferred to the chamber, if the pre-breathing has been carried out elsewhere, and strapped into his seat. Safety pressure is maintained throughout this move and, indeed, throughout the ascent. When the subject is comfortably seated in the small compartment of the chamber, under direct observation of the senior medical officer, and all equipment and monitoring connections have been made and confirmed the decompression profile can begin.

All procedures are carried out with reference to a common checklist used by all members of the team. When all members, including the subject, have confirmed readiness to proceed the initial ascent is begun, at a rate of 4,000ft/min. At this time the interconnecting door between the large and small compartments of the hypobaric chamber is open and the safety officer can sit with the subject. After a regulator check at 10,000ft ascent to the initial altitude of 18,000ft can continue. At 18,000ft the chamber altitude is held and a number of equipment checks are performed. Depending on the type of breathing regulator in use it may be necessary to adjust the regulator at this point to prevent an excess degree of safety pressure building-up. On satisfactory completion of these base altitude checks, the interconnecting door is closed and the small compartment is further decompressed to 25,000ft at a rate of 4,000ft/min, leaving the safety officer at the base altitude in the large compartment of the chamber

When the subject reaches the pre-RD altitude of 25,000ft the chamber is again stabilised and a series of pre-RD checks carried out. When these are complete and the subject has indicated his readiness to proceed a countdown from "5" to "Now" (zero) to the decompression is begun. Just as he had previously done with each pressure breathing exercise the subject takes a normal inhalation on the counts of 5,4,3, followed by exhalation on the counts of 2,1, NOW. On the final count the RD valve is opened and the small compartment of the chamber decompresses, over three seconds, to 56,000ft. Pressure breathing at 70mmHg is automatically provided by the breathing regulator. The subject rolls the mask toggle down and adopts the same breathing pattern he used the previous day throughout all the training exercises. The senior medical officer maintains eye-contact with the subject throughout, occasionally asking for a positive signal (a thumbs-up) of willingness to continue at altitude. The final altitude of 56,000ft is maintained for 30 seconds and with it a steady breathing pressure of 70mmHg. The subject is encouraged by the medical officer throughout the time at altitude and, if necessary reminded to maintain the appropriate breathing pattern. At the end of 30 seconds the recompression of the chamber is begun, reducing the altitude in the small compartment at a rate of 10,000ft/min. During this descent the breathing pressure slowly decays until, as the chamber altitude reaches 40,000ft the only positive pressure remaining is the same degree of safety pressure as the subject had previously experienced.

Throughout the RD and the subsequent time at high altitude the second medical officer monitors the physiological measurements of the subject. If he is concerned about any apparently unsatisfactory change he can either report the matter immediately to the senior medical officer or, indeed, order an immediate descent of the chamber himself. In any event the senior medical officer regularly requests statements on the physiological fitness of the subject to continue the decompression from the second medical officer.

The chamber decent is continued, at 10,00ft/min until an altitude of 25,000ft is reached, at which point the chamber descent is slowed to 4,000ft/min. At 18,000ft the interconnecting door can be opened and the safety officer may rejoin the subject. Below 10,000ft both can lower their oxygen masks if they wish, but keep them close-by for communication purposes; their microphones are in their masks.

Once the chamber has reached ground-level the subject is unstrapped and disconnected from the instrumentation and life support system. He is then allowed to vacate the chamber. A debrief is conducted thereafter with the senior medical officer and any points raised discussed.

On satisfactory completion of this training the individual is cleared to operate very high altitude aircraft in which partial pressure assemblies are worn. Refresher training is carried out in accordance with NATO STANNAG 3114.

Were an emergency to occur with a subject in the chamber at high altitude the decompression can be terminated immediately, with an accelerated descent towards ground-level initiated quickly. The safety officer can be decompressed to join the subject at an intermediate altitude if necessary and then he can attend to immediate needs. Full physiological monitoring throughout the training and RD helps to reduce the risk of this event but it is necessary to be fully prepared for any emergency, occurring either as a result of the decompression itself, or as a consequence of the high breathing pressure required. Specific hazards include cerebral arterial gas embolus, pressure breathing syncope, GI tract distension, hypoxia and decompression sickness.

Future Requirement

Whilst the number undergoing this training in the RAF have been relatively low in the last few years, essential identical training has been carried out on NASA flight test crew for some years. With the introduction into RAF service of new high altitude, high performance aircraft the need for this type of training will increase, and very substantially so. It is necessary, therefore, that provision be made for an adequate number of suitably trained and experienced individuals to be available to carry out this essential aspect of aircrew aeromedical training if we are to continue to avoid severe adverse physiological incidents occurring at very high altitude in the event of an aircraft decompression.

Aviation Physiology and Medicine Training in the Royal Netherlands Air Force & Aeromedical Institute

Major M. J.B. Los, Flight Surgeon
Royal Netherlands Air Force (RNLAF)
Department of Aviation and Occupational Medicine
Section of Aviation Physiology and Aircrew Equipment
Aeromedical Institute
P.O. Box 22 Kampweg 3
3769 ZG Soesterberg
The Netherlands
E-mail: m.los@aeromed.nl

1.1 Organisation

Nearly all aviation physiology and aviation medicine training, from here on referred to as 'aeromedical training' is performed at the Aeromedical Institute. In this civilian non-governmental institute both RNLAF and civilian personnel are involved in aeromedical (and psychological) training, selection, examinations and research for military and civilian aircrew from many countries.

The training section within the Aeromedical Institute currently consists of four RNLAF Aviation Physiologists and a RNLAF Flight Surgeon. Besides training they are also involved in aircrew equipment, especially oxygen systems and anti-G protection. They also participate in aeromedical evaluations and research generally when the human centrifuge and the hypobaric chambers are involved. The latest asset of the training section is a six axis FSDD which stands for Flight Simulated Disorientation Demonstrator.

1.2 Aeromedical training

1.2.1 Visiting aircrew

As mentioned above the training section is visited by aircrew from many countries, both NATO and non-NATO. Although these non-NATO countries are obviously not committed to NATO standards, STANAGS 3114 and 3827 are the basis for the RNLAF syllabus and most training programs. In this paper the emphasis will be on the aeromedical training for aircrew of the Royal Netherlands Armed Forces, but it will also deal with international training and the different approaches to aeromedical training.

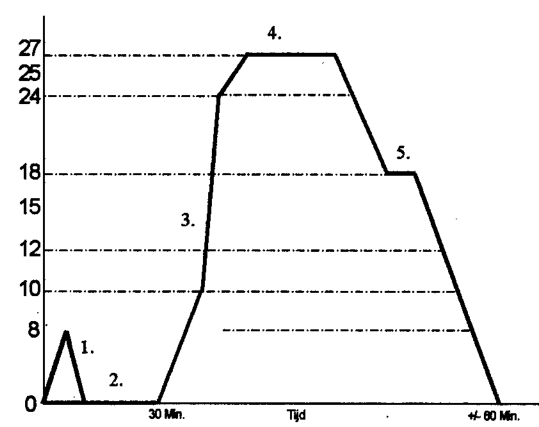
1.2.2 General approach

Training programs for Dutch military aircrew can be grossly divided into elementary aeromedical training for undergraduate pilots and initial and refresher training for pilots/aircrew of:
- the F-16
- rotary wing aircraft
- transport aircraft

1.2.3 Altitude physiology

For all these aircrew altitude physiology including oxygen systems is still the most important training subject. All training programs, also for rotary wing aircrew, include the theoretical training in altitude physiology, followed by a 'flight' in the hypobaric chamber.
The following diagram shows the hypobaric training profile that is used in most training programs.

↑ Altitude in ft (x 1000)



→ Time

Fig. 1: Standard hypobaric chamber flight-profile

It includes the following items:
1. Ear and sinus check to 8000 ft and back at an ascent and descent rate of 3000 ft/minute
2. Denitrogenition with 100% Oxygen for 30 minutes
3. Ascent to 10.000 ft at 4000 ft/minute followed by a rapid decompression or rapid ascent to 24.000 ft depending on the type of aircraft
4. Hypoxia demonstrations at 27.000 ft
5. Night vision demonstration at 18.000 ft

The denitrogenition phase is included to reduce the chances of decompression sickness (DCS). There haven't been any cases of DCS related to the hypobaric training in the last two years. The night vision demonstration is used to show aircrew the effects of mild hypoxia on colour vision and visual acuity. Besides the slight pressure which is felt by the aircrew during the stay at 27.000 ft there is also a demonstration of pressure breathing somewhere in the flight by the use of the emergency setting on the oxygen panel. A total 'flight' usually takes one hour.

1.2.4 Anti-G training: primary

There are two major anti-G training programs for Dutch pilots. One is for all undergraduate pilots before they actually start flying in the RNLAF PC-7 training

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

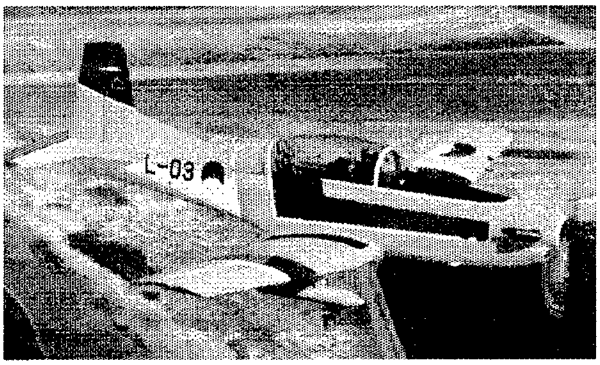


Fig. 2 : RNLAF Pilatus PC-7 Training Aircraft

aircraft which can generate acceleration forces up to +6 Gz. This program is called the 'G-awareness program'. It includes among others the theory of the effects of acceleration forces on the human body and the different defence mechanisms. The theory is followed by three runs in the human centrifuge. The first run in any centrifuge training is always the 'relaxed G profile' or RELG run with a Gz onset rate of 0.1 G/second during which the pilots do not wear their anti-G suit and do not perform the Anti-G Straining Manoeuvre (AGSM). This run is used to show the effects of slowly increasing Gz forces and the related visual symptoms.

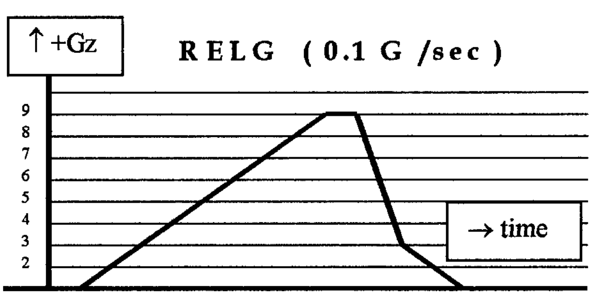


Fig. 3: Human centrifuge Relaxed G (RELG) profile

like grey-out and tunnel vision. The trainees are instructed to terminate the profile when these visual symptoms occur. Two profiles with higher Gz levels (max. 4/5 +Gz) follow the RELG profile. These profiles are called the EMVO 4 and 5 profiles (EMVO

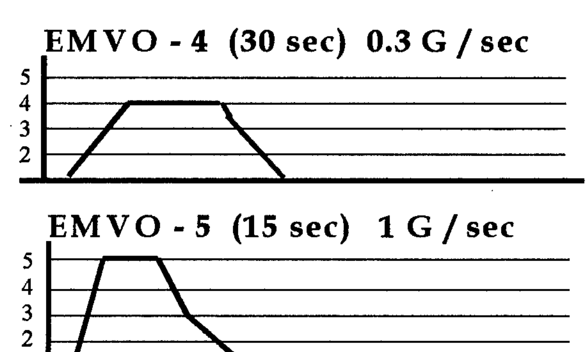


Fig. 4: The EMVO 4 & 5 G profiles

being the Dutch abbreviation for elementary military flight training). These profiles are especially used to train basics of the Anti-G Straining Manoeuvre (AGSM) and they are performed without anti-G protective equipment; comparable to the situation in the training aircraft. The pilots have to complete the full training while showing the essentials of the AGSM before they can enter the actual pilot training.

1.2.5 Anti-G training: advanced

After the undergraduate pilot training a second selection determines which pilots enter the F-16 training program. This program starts with the Euro NATO Joint Jet Pilot Training (ENJJPT) at Sheppard AFB in the United States. ENJJPT is followed by the actual basic F-16 training by the Air National Guard in Tucson, Arizona, but before they start this training and flying in the F-16, the Dutch pilots visit the Aeromedical Institute in the Netherlands for their advanced anti-G training. This training includes the necessary academics followed by the practical training in the human centrifuge with four training profiles. The first profile is the RELG profile, followed by the High Sustained G-6 profile or HSG-6 profile. From this second profile on the pilots wear their anti-G trousers.

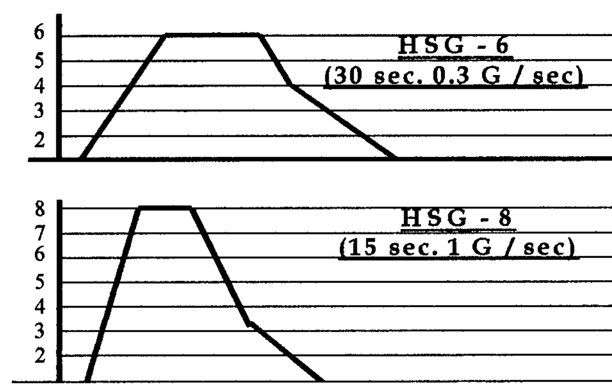


Fig. 5: HSG 6 & 8 G profiles

The HSG-6 profile has a 6 Gz plateau lasting 30 seconds which is typically used to learn the proper combination of adequate muscle tension in combination with the right breathing technique. In the HSG-8 profile the pilots can prove that their AGSM technique is also sufficient at a higher G-onset rates of 1 G/sec and high peak G levels. The pilots pass the training when they complete the HSG-8 run while showing an adequate AGSM. This means they can enter the practical training in the F-16. There is however a fourth profile which although not compulsory is completed by most pilots. It is the Air Combat Manouevre-9 or ACM-9 profile including 2 peaks of 9 and 8.5 + Gz with a 3.5 G/sec onset rate.

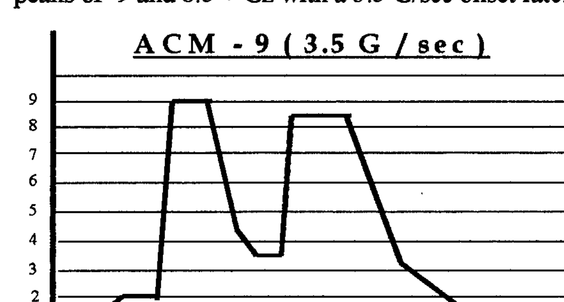


Fig. 6: The ACM-9 G profile

1.2.6 Centrifuge; general information

The human centrifuge can be 'flown' manually but during training the G-profiles and G-levels are generated by the computer. The rationale for this is that the trainees can fully concentrate on the AGSM technique without the distractions from 'flying' the centrifuge. It also decreases the chances of motion sickness. In all cases the computer generates an outside view with a simulated Heads-Up-Display or HUD. The centrifuge does not yet have the necessary equipment for positive pressure breathing. Medical monitoring is limited to an ECG and the visual and auditory information from the trainee. Research projects are taking place which will hopefully produce validated quantitative hemodynamic information about the condition of the trainee and the quality of his or her AGSM technique.

1.2.7 Other lecture subjects

1.2.7.1 Spatial disorientation

For a long period training in this area has been limited to academics due to the lack of a training apparatus. The growing concerns about the dangers of disorientation in aviation have lead to the formation of a basic disorientation demonstration program for undergraduate pilots and the recent arrival of the Flight Simulated Disorientation Demonstrator built in Austria. The RNLAF future plans imply the formation of disorientation training for its pilots in four phases:

1 Basic disorientation training program in the ground school period cq before the actual flight training
2 Disorientation awareness (and demonstrations) during flight training
3 Advanced disorientation training program
4 Refresher courses

In the phases 1,3 and 4 advanced disorientation demonstrators/trainers will be available as well as enhanced presentation tools (fig. 7).

1.2.7.2 Vision

Lectures on vision used to deal primarily with day- and unaided night vision. The large-scale use of Night Vision Devices in the RNLAF has lead to the formation of specific academic training in this area

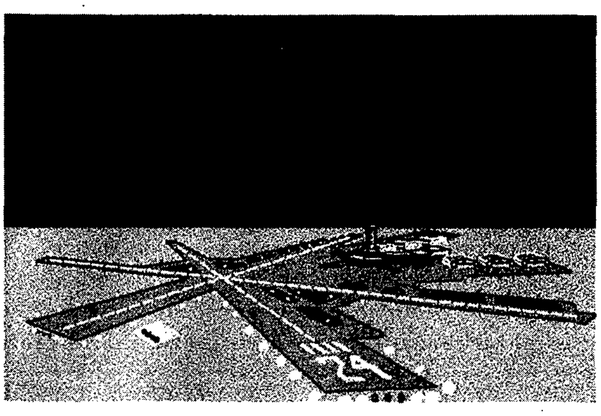


Fig. 7: Example of a power point presentation used to show the different types of disorientation from visual illusions

with the help of the experience and training materials of the USAF and the RAF. There are concrete plans to add terrain boards and other practical tools to the training equipment in the near future.

1.2.7.3 Physical fitness

Considerable attention is given to this subject. The lectures which are given by an exercise physiologist deal with many different relevant aspects of fitness in aircrew like workload, posture, vibration, nutrition, dehydration, neck muscle training, performance under thermal stress etc. This physiologist is also involved in the design of specific exercise testing for different professions in the RNLAF, including pilots.

1.2.7.4 Fatigue

Lectures in this area have been given by both aviation psychologists and physicians, dealing with the causes and prevention of sleep deprivation and fatigue. There will clearly be further emphasis on this area in relation with the increase in night- and out of area operations.

1.2.7.5 Related courses

Other aircrew training is performed by different institutes within the RNLAF:

- RNLAF Survival training centre for subjects like parachute jumping, sea survival and escape from the aircraft
- RNLAF Behavioural Sciences for Crew/Cockpit Resource Management Courses (also performed at the Aeromedical Institute for civil aviators)

1.3 Duration and frequency of courses

1.3.1 Undergraduate pilot training

Undergraduate pilot training for both the RNLAF and the Royal Netherlands Navy takes place at the RNLAF Elementary Military Flight Training School. The elementary aeromedical training at the aeromedical institute for these pilots currently takes three days:

- The first day is scheduled for academics in altitude physiology and oxygen systems followed by practical training in the hypobaric chamber.
- The second day currently contains all academic training, other then in the specific training programs.
- The third day is for academic training in acceleration forces or G-forces, followed by training in the human centrifuge.

Besides this block training, a supplementary day is scheduled for the basic disorientation training. Basic survival training takes several days.
The instructors on the elementary military flight school PC7 aircraft who may be former pilots of all RNLAF and Navy aircraft follow a similar but more compact course of two days. Many of these pilots do not have 'G-experience' and therefore need the same training in this area as the undergraduate pilots.

1.3.2 Other RNLAF courses

The other aeromedical initial and refresher (continuation) courses are:

- Advanced G-training for future F-16 pilots
- Initial training for rotary wing crew
- Refresher training for rotary wing aircrew
- Refresher training for fixed wing transport aircrew
- Initial training for F-16 pilots
- Refresher training for F-16 pilots
- Initial altitude physiology for medical aircrew

These courses take one day. All refresher training includes practical altitude training in the hypobaric chamber.

1.3.3 Frequency

All RNLAF aircrew are obliged to attend refresher or continuation training every three years. The decision whether this periodicity should be changed into a five year cycle has not yet been made.

1.4 Other national courses

1.4.1 The Royal Netherlands Navy

The RNLAF and Aeromedical Institute also provide aeromedical training for the Royal Netherlands Navy and Army. As already mentioned at the RNLAF Elementary Military Flight Training School both Air Force and Navy undergraduate pilots are trained. For aircrew of the P3C Orion an Altitude Physiology Course is organised which has a periodicity of three years. It includes practical training in the hypobaric chamber with a flight-profile similar to that in fig. 1.

1.4.2 The Royal Netherlands Army

For the commando's of the Royal Netherlands Army who are active in high-altitude parachute jumping a special one day course has been designed. It is called the HAHO/HALO Course which stands for High Altitude High Opening and High Altitude Low Opening. The course includes academics with altitude physiology and special attention to the oxygen equipment and practical training in the hypobaric chamber. The flight in the hypobaric chamber (fig. 8) includes:

1. ascent to 25.000 ft at 4000 ft/min
2. a simulated free-fall from 24.000 to 10.000 ft
3. a rapid decompression at 5000 ft/min.

There is a related training for the oxygen masters which takes two days.

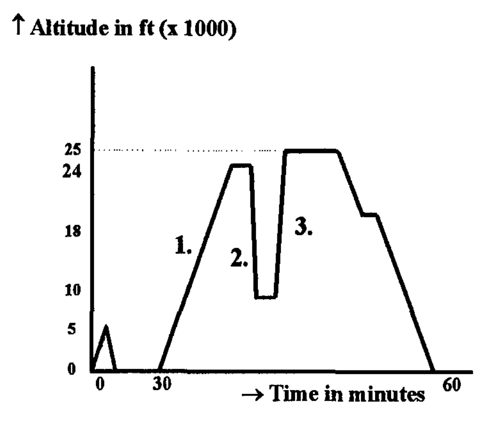


Fig. 8: HAHO/HALO chamber flight-profile

Civil aviation

1.4.2.1 Altitude physiology

The Aeromedical Institute Training Section is responsible for the theoretical aviation physiology training for some categories of undergraduate civilian pilots. It offers a practical altitude physiology training in the hypobaric chamber on a voluntary basis to any civilian pilot. For the undergraduate pilots of one of the Dutch civilian flight schools the chamber flight is compulsory.

1.4.2.2 Acceleration forces

The Aeromedical Institute has recently decided to offer one-day training courses in this area to civilian aerobatics pilots. These pilots endure moderate to high positive and negative Gz forces during their aerobatics manoeuvres. The training includes the necessary physiological academics followed by AGSM training in the human centrifuge.

1.5 International courses

1.5.1 US Air Force

The United States Air Force in Europe (USAFE) uses the training facilities of the Aeromedical Institute on a regular basis. The RNLAF/Aeromedical Institute Aerospace Physiology and Centrifuge Training Programs are officially recognised by the USAF.

The academic physiological training is instructed mainly by a USAFE Physiological Training Officer (PTO) and the practical training of USAFE aircrew in the hypobaric chamber and human centrifuge is a joint effort between the USAFE and RNLAF PTO's. Most of this practical training is in the hypobaric chamber. There is no initial centrifuge training for USAFE pilots in the Dutch human centrifuge. USAF however, unlike the RNLAF, has regulations which implicate continuation centrifuge training for certain groups of pilots. These pilots visit our centre regularly.

1.5.2 Other NATO allies en friendly countries

As mentioned earlier the RNLAF & Aeromedical Institute train aircrew from many nations and STANAGS 3114 and 3827 form the basis of this training. Pilots visiting the Aeromedical Institute for training in the Human Centrifuge other then from USAFE come from among others:

• Belgium	• Denmark
• Greece	• Portugal
• Spain	• United Arabic Emirates

Theoretical and practical altitude physiology is instructed to Italian E3A AWACS aircrew.

1.6 Different approaches

1.6.1 Altitude physiology

Although the RNLAF does not have a reservation on STANAG 3114, it no longer performs practical altitude training in the hypobaric chamber for its own aircrew above 27.000 ft. One of the reasons for this is that the RNLAF pilots go through extensive aeromedical training again when they enter the ENJJPT training at

Sheppard AFB in the US. Furthermore the RNLAF aeromedical trainers believe that most if not all aspects of the stay at higher altitudes like pressure breathing can be demonstrated at lower levels as well. It is the opinion that there is hardly any surplus value of climbing to higher levels especially considering the added risk of Decompression Sickness. We do however still perform chamber flights to 35.000 and occasionally to 43.000 ft for USAFE aircrew. Many other different opinions about altitude physiology were covered extensively during the RTA/HFM workshop.

1.6.2 Centrifuge training

1.6.2.1 Monitoring

Different international approaches exist in the area of monitoring, the different centrifuge profiles, selection for G-tolerance and the necessity of continuation training. The RNLAF has always monitored the cardiac condition of the centrifuge trainees through an ECG and it believes that this is not only a conditio sine qua non but that new ways of hemodynamic monitoring are highly needed.
The US Navy and US Air Force however do not require ECG monitoring during centrifuge training. The US Air Force reservation on STANAG 3827 mentions the possible career threat of ECG monitoring. This is quite understandable when one considers how little is known about the clinical relevance and the hemodynamic consequences of ECG abnormalities under G. One of the ways to handle this issue might be by international co-operation between the different 'trainers' and the aggregation of training data.

1.6.2.2 Centrifuge profiles

The minimum G-levels which a pilot must endure to qualify for the 'High-G' environment are stated in STANAG 3827 as well as the minimum G-onset rate. There are however differences in aspects of the centrifuge training other then the minimum G-levels. One of the differences is for instance the 'check 6 profile' where the pilot has to rotate his neck 90 degrees prior to the high-G profiles. Another example was shown during the workshop of a high-G profile with four G-peaks of 8 to 9 +Gz in one profile.

1.6.2.3 Selection

The RNLAF unlike for instance the German Luftwaffe and Polish Air Force does not select its future jet pilots through G-tolerance qualifications. There are different opinions internationally about the value of the relaxed G-tolerance. With our current monitoring the relaxed G-value remains a subjective measurement. The moment at which the trainees determine to stop the centrifuge run obviously varies and it is likely that a certain number of trainees are not as 'relaxed' as they are supposed to be. EMG monitoring clearly shows this.
Although not intended as such the human centrifuge sometimes does turn out to function as a medical selection tool when undergraduate pilots do not pass the training because of severe ECG abnormalities, like a previously undetected WPW, or a abnormally low G-tolerance. The latter is or better was often due to cardiac valve anomalies. This has been one of the reasons for the RNLAF to introduce Echocardiography as a standard examination in medical selection.

1.6.2.4 Refresher/continuation

The RNLAF does not require refresher centrifuge training for its F-16 pilots after longer non-flying periods. Currently the only reason for an experienced F-16 pilot to get into the centrifuge would be a medical evaluation for instance in case of anti-hypertensive medication. The USAF has regulations which implicate that pilots who have not flown in the high-G environment for longer then three years need continuation centrifuge training. USAFE fighter pilots regularly visit the human centrifuge in the Netherlands for training. The RNLAF aeromedical trainers consider this a very sensible regulation which should be introduced in the RNLAF as well.

1.7 Future developments

In the near future the emphasis within the training section will be on the development of the practical disorientation training program in the FSDD which has recently been installed. Further emphasis will be on the development of training programs for the aircrew who are and will be flying with Night Vision Devices.

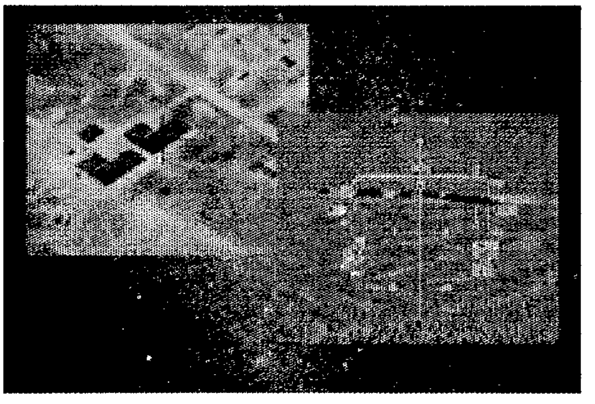


Fig. 8: Infrared pictures from comprehensive USAF briefing material on the aeromedical aspects of Night Vision Devices and Operations which is thankfully used in RNLAF aircrew briefings.

There is a growing involvement of the section in the evaluation and testing of aircrew equipment like NBC ensembles and LASER protection. We would like to expand this involvement in co-operation with the different defence-research institutes. The training facilities/hardware, especially the desired new human centrifuge could play an important role within this development. The aeromedical aspects of the new aircrew equipment will have to be dealt with in the different training programs.

1.8 Finally: the statistics

In 1998 a total of 1106 aircrew were trained;

- Academics only 275
- Hypobaric training 699
- Centrifuge training 208

There were no (known) cases of DCS.

In-Flight Demonstration of Spatial Disorientation in the British Army

M. G. Braithwaite
Headquarters Director Army Aviation
Middle Wallop, Hampshire, United Kingdom, SO20 8DY

A description of the British Army Spatial Disorientation Demonstration Sortie and an evaluation in the USA have been comprehensively reported previously in these two articles, which are reproduced here with the kind permission of the Editor of *Aviation, Space and Environmental Medicine:*

1. Braithwaite MG. The British Army Air Corps In-Flight Spatial Disorientation Demonstration Sortie. Aviation, Space and Environmental Medicine, 68, 1997, 342-345.

2. Braithwaite MG, Hudgens JJ, Estrada A, Alvarez EA. An Evaluation of the British Army Spatial Disorientation Sortie in U.S. Army Aviation. Aviation, Space and Environmental Medicine, 69, 1998, 727-732.

The British Army Air Corps In-Flight Spatial Disorientation Demonstration Sortie

MALCOLM G. BRAITHWAITE, M.B., M.F.O.M.

BRAITHWAITE MG. *The British Army Air Corps spatial disorientation demonstration sortie.* **Aviat Space Environ Med 1997; 68:342–5.**
Following didactic instruction, most aircrew are able to experience some of the disorientating illusions and limitations of the orientational senses in a variety of ground-based devices. In order to reinforce instruction in spatial disorientation (SD) within the environment in which they operate, British Army Air Corps helicopter pilots also receive an airborne demonstration of the limitations of their orientation senses. Since 1982, a specific SD sortie has been programmed towards the end of the basic rotary-wing phase of flight training approximately 6 weeks after the aeromedical training module, and before students commence rotary-wing instrument flight training. Refresher sorties are flown every 4 years. The conduct of the SD sortie is described in detail. Analysis of helicopter accidents demonstrates that this training is operationally effective by contributing towards the reduction of SD-related mishaps. It is cost-effective and the addition of this type of in-flight demonstration to the aeromedical training syllabus is regarded as being of great value to British Army helicopter aircrew. Similar instruction could be readily adopted by other services.

DEMONSTRATION OF SOME of the illusions of spatial disorientation (SD) and the limitations of the orientational senses during ground-based training is a vital part of the proper education of aviators. Most student pilots are given instruction during their flight training on how to overcome the effects of SD, but few air forces provide a specific SD demonstration sortie to reinforce the knowledge gained during ground-based training.

There is a distinct difference between in-flight demonstration of SD, and training to overcome the problem once it has occurred. A demonstration of SD consists of reinforcement of the limitations of the orientation senses in flight and the enhancement of aircrew awareness to potentially disorientating situations. SD training, on the other hand, consists of a series of flight procedures to cope with disorientating circumstances and illusions (e.g., recovery from unusual attitudes during instrument flying). SD training is clearly the responsibility of the flight instructor in both simulator and actual flying sorties, while the demonstration of physiological limitations is best conducted by the flight surgeon pilot who, having performed the ground-based training, is on-hand to explain the mechanics of SD.

A specific British Army spatial disorientation sortie was developed and has been conducted since 1982. Although the U.S. Air Force used to fly a similar sortie, no other nations or services are known to currently enhance the awareness of aircrew in their physiological limitations in this way.* The aim of the SD demonstration sortie is to reinforce, in a real environment, the ground training received in SD and consequently increase the awareness of trainee pilots. The objective has been to provide aircrew with an initial SD demonstration sortie and a refresher every 4 years. This has been achieved in the main since it has become a mandatory requirement of aircrew

*Braithwaite MG. Towards standardization in spatial disorientation. Position paper to Working Party 61 of the Air Standardization Coordination Committee, September 1994.

From the U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL.

This manuscript was received for review in February 1996. It was revised in June and December and accepted for publication in December 1996.

Address reprint requests to: Commander, U.S. Aeromedical Research Laboratory, Attn: MCMR-UAS-AF/Dr. M. G. Braithwaite, P.O. Box 620577, Fort Rucker, AL 36362-0577. Dr. Braithwaite is a Consultant in Aviation Medicine and is the U.K.-U.S. Exchange Research Flight Surgeon in the Aircrew Factors Branch, Aircrew Health and Performance Division, USAARL.

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

continuation training. This paper describes the conduct of the sortie and discusses the operational and cost benefits.

Description of the SD Demonstration Sortie

The sortie is flown by a pilot-physician (Flight Surgeon) in the Gazelle AH1 helicopter (SA 341). Three students can be flown on each sortie, one in the copilot's seat and two in the rear passenger seats. It can be completed in about 25 to 30 min flight time, so 12 students can receive the demonstration in 2 h. The sortie was originally adapted from those described in Benson (1) and has since been modified from the description provided by Edgington and Box (4).

Typically, students have had about 100 h basic fixed-wing and basic helicopter experience and will fly the sortie before they start rotary-wing instrument flight training. They will have completed the classroom aviation medicine and disorientation training a few weeks prior to the sortie.

General reassurance is given that no violent maneuvers will be flown, and that only one student will have his or her eyes shut at any one time for no more than a minute or so. During each demonstration the subject student gives a running commentary of his/her perception of orientation with particular reference to pressure altitude, heading and airspeed. Primarily for flight safety reasons, the sortie is best flown in good visual meteorological conditions (VMC) but since it is difficult to completely prevent transmission of light to the eyes, bright sunlight is best avoided. In order to save time, the sortie is conducted close to the base airfield, but an area of low aviation activity is chosen for safety. The observing students are also instructed to assist with aircraft lookout.

During the transit to the exercise area, the use of the special senses in orientation is only briefly reviewed as initial students have received classroom instruction a few weeks prior to the sortie, and refresher students, a lecture on the same day as the sortie. The overwhelming contribution of vision to orientation is stressed together with the fact that SD is primarily a problem associated with poor external visual conditions, thus emphasizing why the students will be deprived of their vision during the exercises.

The specific maneuvers have been chosen on the basis that they are simple to perform, are easily repeatable and have operational relevance to the most commonly experienced types and degrees of SD. At the commencement of each maneuver, the subject student is told to sit free of the controls and airframe structures other than the seat, note the aircraft's initial flight parameters and then to close his or her eyes and give a running commentary as described above. The other students are asked to observe but not comment until after the maneuver. Each student experiences at least one exercise in each of the forward flight and hover groups.

Forward Flight

Exercise 1: Straight and level flight is established at 100 knots. After 10 s, a gently increasing (suprathreshold) roll to 30° angle of bank is commenced while maintaining airspeed and pressure altitude. This is stabilized and, on completion of a 360° turn, the aircraft is rolled wings level again at a suprathreshold rate. The onset of the roll is normally detected, but as the semicircular canal response decays, a false sensation of a return to straight and level flight is perceived. As the roll to level flight is made, a sensation of turning in the opposite direction is perceived. The student is told to open his or her eyes once he considers that he or she is again straight and level. The observing students are asked to tell the subject what actually happened and all are asked for their comments. The flight surgeon will then remind the students of the physiology of semicircular canal performance.

Exercise 2: Straight and level flight is established at 100 kn and one of the other students is asked to close his or her eyes. The aircraft is flown with no alteration of height, heading, or airspeed. Because of small aircraft movements from turbulence and the aerodynamic response of the helicopter which stimulate the kinaestheic and/or the vestibular apparatus above threshold, all students perceive climb, descents, or turns in unpredictable and varying amounts. The erroneous sensations produced by brief stimulation of the kinaestheic receptors and vestibular apparatus is discussed.

Exercise 3: Straight and level flight is established at 100 kn into wind, and once the subject has closed his or her eyes, the helicopter is slowed within 30–40 s to a free air hover with no change of heading or height. Both the deceleration and the nose-up pitch associated with the attitude change when slowing the aircraft convinces the student that a climb is taking place. In addition, a turn is often falsely perceived when balance variations are made to keep straight. The somatogravic illusion is discussed.

Exercise 4: This maneuver is best conducted from 500 ft above ground level. Straight and level flight is established at 100 kn and the student closes his or her eyes. A sub-threshold descending turn is commenced as gently as possible. Within 30 s in the Gazelle, it is possible to lose 500 ft in height and turn through 180°. The student, remembering the second demonstration, usually states that he is straight and level. When the aircraft is established in low level flight, the student is asked to report his or her heading and height and airspeed and then open his or her eyes. This demonstration forcibly and convincingly demonstrates a Type 1 orientation error, due to the proximity of the ground.

Hover

The helicopter has a unique ability to accelerate about as well as along orthogonal axes, thus the final series of demonstrations starts from a 5- or 6-ft hover. For this series of exercises, it is most important to check for hazards: the terrain surroundings should be familiar and a good lookout maintained during clearing turns between each exercise. In turn, the three students are exposed to a variety of linear and rotational movements while maintaining hover height. The flight surgeon keeps prompting the subject for a running commentary (to occupy channels of attention) and so exacerbate the onset of SD. Most aircrew are able to maintain their orientation for 10 to 15 s before losing it. Within these exercises it is possible to "hide" various maneuvers so that when the student opens his or her eyes, a dramatic end point is evident:

- a towering vertical climb to 200–300 ft
- climbing backwards at 10–15 kn
- landing without the student realizing it
- a gentle transition to forward flight

These exercises have a most educational effect upon the observing students and are discussed in the context of snow, sand, and night operations.

Additional Exercises

The exercises described above are the recommended minimum. Should time permit, and particularly for refresher training, variations of these exercises and additional ones can be performed:

- Straight and level flight is established at 100 kn, the eyes are closed, and the aircraft dived to a 20° nose down attitude. A steady pull up to 30° nose up is then made with a gentle bunt recovery. Most students perceive a continuing full loop; some experience a barrel roll sensation.
- The reverse of slowing down to a free air hover can be flown, i.e., from a slow speed to maximum cruise speed. Diving sensations are usually perceived.
- From a free-air hover into wind, the aircraft is pitched nose down to approximately 50°. This demonstration is visually stimulating to the observers but the angle of pitch down is generally "under-perceived" by the subject.
- In steep turns each student in turn is invited to perform rapid head movements in pitch or yaw to experience the Coriolis phenomenon.

Debriefing

On the return flight to the base airfield, the sortie is discussed with particular reference to the significance of sub-threshold maneuvers and erroneous sensory information cues. The students are reassured that they are all physiologically normal but just not "designed" for flight. It is stressed that the aim of the sortie has been to provide them with an idea of the limitations of their own physiology in the environment in which they operate and the phases of flight commonly associated with SD. Similarly, they must realize that they have not been trained to overcome the effects of SD. That is the responsibility of their flight instructors to address during later training in the recovery actions from unusual attitudes and procedures upon inadvertent entry into IMC. They are advised that the best that they can do individually with respect to SD, is to achieve and retain currency and competency at instrument flying.

Benefits of the Sortie

Operational Benefits

In order to estimate the benefit of this sortie on British Army Air Corps operations, the non-hostile SD flying accidents (i.e., excluding ground-handling mishaps) were compared between the periods before (1971–1982) (6), and since (1983–1993) (2) the introduction of the sortie. The SD accident rates were 2.04 accidents per 100,000 flying hours and 0.57 accidents per 100,000 flying hours, respectively. Using a Poisson regression analysis (5) the Likelihood Ratio in the Type 3 analysis revealed a significant difference between both the period [Chi square (df = 1) = 5.8563; p = 0.0155], and classification of accident [Chi square (df = 1) = 73.9731; p = 0.0001]. This was interpreted to demonstrate a period effect of a highly significant reduction in the SD accidents rates since the sortie has been introduced.

There are confounding factors in this analysis. Some factors will have tended to reduce the orientation error accident rate: e.g., the introduction to service of aircraft with automatic flight control systems and stability augmentation in the late 1970's; the installation of additional aircraft flight instruments such as radar altimeters in the early 1980's; the phasing out of predominantly single-pilot operations in the mid 1980's and subsequent introduction of two qualified pilot crews for most sorties in the late 1980's; and a reclassification of the accidents to exclude the lesser damaged airframe in 1991. A counterbalancing factor which has tended to increase the orientation error accident rate is the much greater use of night vision goggles since the mid 1980's. These devices, while enhancing external visual cues in the dark, do have considerable limitations in the perception of orientation. Notwithstanding these arguments, it is reasonable to assert that the SD demonstration sortie has contributed to reducing the accident rate in which SD is involved. This is most encouraging, especially as the military flying task is becoming more complex and now leaves little room for error from a physiological limitation such as SD.

Pilot Acceptance

The SD demonstration sortie has gained wide acceptance by Army pilots. It is extremely rare for aircrew not to misperceive their orientation during the maneuvers. In a survey conducted by Durnford (3), 79% of 338 aircrew considered the sortie to be beneficial, 19% were indifferent and only 1% considered it harmful! This finding confirms the subjective value of this additional aeromedical training.

Cost Benefit

From 1982 until September 1995, 1069 initial and 597 refresher students have flown on this sortie. On initial training, 180 Gazelle helicopter flight hours have been logged and 130 hours on refresher training. Using 1996 military operating costs, this represents a total cost over nearly 14 years of $252,000 U.S. This figure is less than one tenth of the replacement cost of the least expensive in-service British Army helicopter, and it would take many years of training at this cost to justify the purchase of a modern electro-mechanical demonstrator.

Conclusion

The SD demonstration sortie has been a most successful enhancement to the aeromedical training of British Army pilots. Both operational and cost benefits are apparent, and aircrew fully appreciate the value of the demonstration. There is, therefore, strong justification for the continuance of the sortie. Furthermore, similar instruction to that described in this paper could be readily adopted by other services. The author is presently conducting an acceptability assessment of this sortie in the U.S. Army and is most willing to communicate directly with interested parties.

ACKNOWLEDGMENTS

I am grateful to Dr. Sam Shannon for his assistance in the statistical analysis of the SD accident data.

The opinions and conclusions above are those of the author and should not be construed as reflecting the policy of the British Army or U.S. Department of Defense.

REFERENCES

1. Benson AJ. Orientation/disorientation training of flying personnel: a working group report. Neuilly-sur-Seine, France: AGARD, 1974; Report No. 62.
2. Braithwaite MG. An aviation medicine review of Army Air Corps helicopter accidents 1983–1993. Defence Research Agency Center for Human Sciences, 1994; Report TR94016.
3. Durnford SJ. Disorientation and flight safety—a survey of UK Army aircrew. Neuilly-sur-Seine: AGARD, 1992; Conference Proceedings 532.
4. Edington K, Box CJ. Disorientation in army helicopter operations. J Soc Occup Med 1982; 32:128–35.
5. SAS/STAT Software GENMOD Procedure for Poisson Regression. Cary, NC: SAS Institute Inc., 1996.
6. Vyrnwy-Jones P. A review of Army Air Corps helicopter accidents 1971–1982. Farnborough, Hants: Royal Air Force Institute of Aviation Medicine, 1984; Report No. 632.

An Evaluation of the British Army Spatial Disorientation Sortie in U.S. Army Aviation

MALCOLM G. BRAITHWAITE M.B., M.F.O.M., JOE J. HUDGENS, ARTHUR ESTRADA, AND EDUARDO A. ALVAREZ

BRAITHWAITE MG, HUDGENS JJ, ESTRADA A, ALVAREZ EA. *An evaluation of the British Army spatial disorientation sortie in U.S. Army aviation.* Aviat Space Environ Med 1998; 69:727–32.

Background: Following didactic instruction, most aircrew are able to experience some of the disorienting illusions and limitations of the orientation senses in a variety of ground-based devices. In order to reinforce instruction in spatial disorientation (SD) within the environment in which they operate, British Army Air Corps helicopter pilots also receive an airborne demonstration of the limitations of their orientation senses prior to rotary-wing instrument flight training. The objective of this assessment was to determine whether the SD demonstration sortie would be an effective adjunct in training aircrew in SD in the U.S. Army. ***Methods***: There were 45 aviators and training personnel who experienced the sortie and gave their opinion in questionnaires. ***Results***: The following conclusions were made: the maneuvers performed in the SD demonstration sortie, and the sortie overall, were extremely effective at demonstrating the limitations of the orientation senses; the SD sortie attracted a significantly higher rating in its effectiveness to train aviators in SD than all the currently available methods; the introduction of the sortie into the initial flight training syllabus would be a distinct enhancement to the SD training of aviators and associated personnel; and the introduction of the sortie into refresher training in field units would also be an advantage. ***Conclusion***: Other services are encouraged to consider this enhancement to the SD training of aviators.

SPATIAL DISORIENTATION (SD) occurs when a pilot fails to correctly perceive the position, motion, or attitude of the aircraft. Such a misperception may have disastrous effects. SD was considered to be a significant factor in 291 (30%) class A-C helicopter accidents in the U.S. Army in the 8-yr period between 1987 and 1995 (2). Some 110 lives were lost in these accidents, and a monetary cost of nearly $468 million was incurred. It should be remembered that only a small proportion of SD episodes lead to accidents, and that non-mishap incidents also impose operational costs in terms of reduced efficiency or abandonment of the mission. In wartime, the risk of SD is heightened by the extra pressure on sensory and cognitive resources. During Operation Desert Shield/Storm, 81% of U.S. Army aviation nighttime accidents were ascribed to SD (5).

One of the most important countermeasures to SD is the aviator's awareness of his physiological vulnerability to SD and the operational circumstances and phases of flight in which SD is most likely to occur. Consequently, all military aviators must attend courses of instruction in SD. Despite regulations that mandate SD training, there is great variability in the quality, quantity, and frequency of this teaching, not only between nations and services within a nation, but within each service itself (1). There is, therefore, room for improvement in all aspects of SD training. It has been long accepted that a demonstration of some of the illusions of SD and the limitations of the orientation senses during ground-based training is a vital part of the proper education of aviators. Most student pilots are given instruction during their flight training on how to overcome the effects of SD, but few air services provide a specific SD demonstration sortie to augment ground-based training. An in-flight demonstration of SD reinforces aircrew knowledge of the limitations of the orientation senses in flight and enhances aircrew awareness of potentially disorienting situations. In-flight SD training, on the other hand, consists of a series of flight procedures to teach aviators how to cope with disorientating circumstances and illusions (e.g., recovery from unusual attitudes during instrument flight). The teaching of recovery sequences is clearly the responsibility of the flight instructor in both simulator and actual flying sorties, while an in-flight demonstration of SD, although it could be performed by specially trained flight instructors, is best conducted by the flight surgeon who, having performed the ground-based training, is on hand to explain the mechanics of SD.

It was in the pursuance of this philosophy that a specific SD demonstration sortie was developed and has been used by the British Army over the last 15 yr. The sortie demonstrates the limitations of their orientation senses to aviators during helicopter maneuvers in flight. The demonstration cannot be conducted in a motion-based simulator because such devices cannot create the appropriate acceleration environment to induce an effective result. The British Army SD sortie has been previously described in detail, and its efficacy both in training aircrew and preventing SD related accidents discussed (3). A recommendation from that paper was its adoption by other services. This paper describes an assessment of the sortie by U.S. Army aviation personnel. During the study, the opportunity was also taken to gain subjective opinions on the current standard of SD training.

METHODS

Under the auspices of a research protocol at the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, the sortie was demonstrated to a cross section of Army aviators and associated personnel (herein referred to as "participants"). There were 45 individuals (including 3 "guest" participants from the U.S. Navy, U.S. Air Force, and Canadian Air Force) who experienced the sortie and gave their opinions in pre- and postflight questionnaires. The Army personnel were generally from one of four groups: instructor pilots (IPs), flight surgeons,

From the U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL.

This manuscript was received for review in July 1997. It was revised in November 1997 and was accepted for publication in December 1997.

Address reprint requests to: Commander, U.S. Aeromedical Research Laboratory (USAARL), ATTN: MCMR-UAS-AF/Dr. M.G. Braithwaite, P.O. Box 620577, Fort Rucker, AL 36362-0577.

Dr. Braithwaite is a Consultant in Aviation Medicine and is the U.K.-U.S. Exchange Research Flight Surgeon in the Aircrew Health and Performance Division, USAARL.

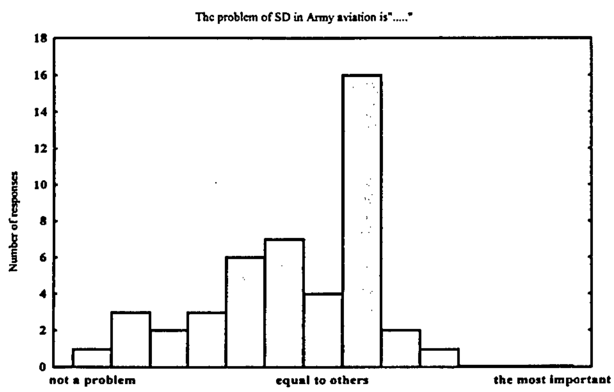


Fig. 1. Assessment of the problem of SD.

aeromedical training staff, and general aviators. All participants voluntarily signed an informed consent approved by the USAARL Human Use Committee.

In the British Army, the pilot-physician both flies and conducts the sortie. However, as U.S. Army flight surgeons are generally not rated aviators, the UH-1 helicopter used in this demonstration was commanded and flown by an IP with a research flight surgeon conducting the sortie from the copilot's seat. Participants were fully briefed on the nature of the sortie, in particular, that the maneuvers were not "violent," that the aim was to augment their ground training by demonstrating the limitations of perception, and that they were not being trained in how to overcome SD. At this stage, participants were asked to complete a short preflight questionnaire about their opinion of the SD hazard and experiences of previous SD training. For questions that required a rated answer, participants were requested to place a check mark on a graduated line at the position that most clearly represented their opinion. The rated score was then calculated by measuring the position of the check mark from 0 (lowest rating) through 7 (medium rating) to 13 (highest rating).

Participants occupied the cabin seats facing forward. Following a transit to the demonstration area, a series of forward flight and hover maneuvers was conducted (3). In turn, each of the three participants on each sortie was asked to sit free of the airframe structures other than the seat, note the aircraft's initial flight parameters, close their eyes and lower their dark visor, and, as the "subject" for that maneuver, give a running commentary on their perception of the aircraft's flight path. In this way, the "subject" was deprived of vision (the most important orientation sense) so that the limitations, particularly the unreliability of the nonvisual orientation senses, could be demonstrated. The other two personnel (observers) were asked to observe but not comment until after the maneuver was complete. The flight surgeon then debriefed the maneuver in flight over the intercom with all participants listening. All personnel experienced at least one maneuver in each of the forward flight and hover groups. Following the flight, personnel were asked to complete another questionnaire asking for their impressions of the sortie. The same rating techniques as the preflight questionnaire were used.

RESULTS

The results of this evaluation are based on analysis of the pre- and postflight questionnaire data. Some additional comments from those experiencing the SD demonstration sortie are also recorded.

Assessment of the Problem of SD

Participants were asked their opinion of the magnitude of the problem of SD. The distribution of responses is shown in **Fig. 1**, and two of the additional comments were as follows: "SD needs particular emphasis in noninstrument rated airframes to avoid catastrophic first encounters with disorienting circumstances;" and "there is an increased danger of SD in flight with night vision devices (NVDs)."

Assessment of the Standard of SD Training

The distributions of opinion of current SD training are shown in **Fig. 2, Fig. 3,** and **Fig. 4**. Not all participants had experienced all the forms of SD training, hence the disparity in response numbers. Some frequently cited comments were as follows: "SD needs to be taught more effectively to all crewmembers;" "SD is not stressed enough during transition training;" "the only refresher training conducted is unusual attitude recovery and memorization of illusions without real understanding;" and "there are little or no simulator or airborne SD correction or avoidance procedures taught."

Assessment of the Types of SD Training (Pre-Sortie)

Before the SD demonstration sortie, personnel were asked to rate the types of SD training they had experienced. **Table I** summarizes these responses. Two of the more frequently cited comments were as follows: "In group discussions, pilots are hesitant to admit their experiences;" and "recovery from unusual attitude training depends on the enthusiasm of the IPs." It must be noted that some aeromedical training instructors had had the opportunity to experience the advanced spatial disorientation demonstrator (ASDD) at the U.S. Air Force School of Aviation Medicine, Brooks AFB, TX. This centrifuge device (6) has been developed to demonstrate various aspects of SD. However, it uses fixed wing profiles, most of which have little relevance to the present rotary-wing manifestations of SD (2,5).

Assessment of the SD Sortie Maneuvers

Participants were asked to rate each maneuver and the sortie overall, on its ability to convince them that their

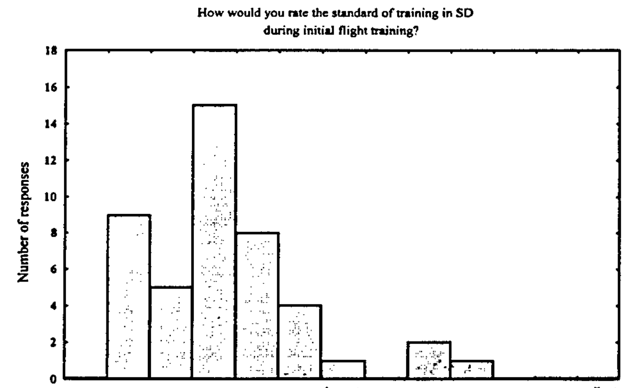


Fig. 2. Assessment of the standard of initial SD training.

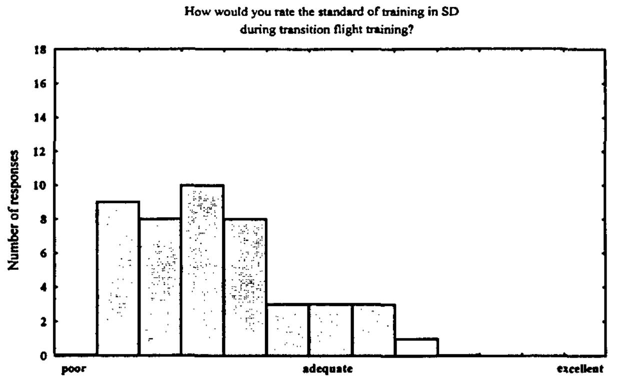


Fig. 3. Assessment of the standard of transition of SD training.

nonvisual senses were unable to give them accurate orientation information.

The questions posed are reproduced below together with some additional comments on the maneuvers. The distribution of ratings for the individual maneuvers and the sortie overall for both subjects (n = 15) and observers, (n = 30) is shown in **Table II.**

Level turn maneuver: Question: "How successful would you rate the level turn maneuver in its ability to convince you that it is difficult for you to sense motion and attitude without aircraft instruments?" Comments: "I felt the initial turn and thought we had leveled off after 15 s" (five participants made this comment); and "an excellent demonstration of a subthreshold maneuver."

Straight and level maneuver: Question: "How successful would you rate the straight and level maneuver in its ability to convince you that random motion experienced in flight (e.g., turbulence) can give you the wrong information?" Comments: "A very clear demonstration; i.e., in the absence of real movement, the mind generates its own motion," "random movements in turbulence completely confused the subject;" and "this demonstration was particularly convincing in that the normal vibration of the aircraft can fool you into thinking that you are climbing or turning."

Straight and level deceleration to 30 kt: Question: "How successful would you rate the deceleration maneuver in its combined ability to demonstrate both the illusion of climbing when the aircraft is pitched nose up, and the inability to accurately detect airspeed changes without reference to flight instruments?" Comments: "The subject actually believed the aircraft was climbing, which was a surprise for me (with my eyes open), and also, as he was unfamiliar with the UH-1, he didn't detect the deceleration from changes in the main rotor blade noise;" and "one's vestibular system simply cannot keep up with motion changes without visual reference."

Inadvertent descent: Question: "How successful would you rate the inadvertent descent maneuver in its ability to convince you that it is difficult to accurately sense the position, motion, and attitude of the aircraft when close to the ground in conditions of poor visibility?" Comments: "I felt the initial descent, and that we were turning right, but I thought that we had descended only 200–300 ft—on opening my eyes, I saw we were only 50 ft above the ground;" "with a gradual descent one never feels the descent after the initial motion;" and "excellent demonstration, it was the best of the forward flight series."

Hover maneuvers: Question: "How successful would you rate the hover demonstrations in their ability to convince you that it is difficult to accurately sense the position, motion, and attitude of the aircraft when close to the ground in conditions of poor visibility?" Participants were asked to rate their experience of the hover maneuvers as a whole. Comments: "I thought that we were in a right pedal turn, then a left pedal turn, when we were actually on the ground;" "this is a good exercise to show Apache pilots that, in the hover at night, they cannot trust their instincts;" "I could not tell when we were drifting backwards or sideways at all;" "it was even more difficult to perceive orientation in the hover than in the forward flight demonstrations;" "I recall my earliest demonstration regarding the cumulative degrading effects of SD in 1982 when I was unable to accurately determine my aircraft's attitude and position—now 14 yr and 7000 flight hours later, I am no better;" "only attitude and yaw changes could be felt—no drift could be felt at all;" "the cumulative affect was complete disorientation;" "I was really amazed that I could not detect the lateral drifts while at a hover, and I now know why we have so many main rotor blade and tail strikes;" "this graphically demonstrates what could happen in white-out or brownout;" "when listening to the subject's narrative, one can easily see how there is sensory confusion without visual reference;" and "the best of the maneuvers and reinforced my respect for SD."

The sortie overall: Question: "Overall, how well did this demonstration sortie show the limitations of the orientation senses in flight?" Comments: "This demonstration reinforces all previous academic training to make a more lasting impression;" "one is not really aware of one's sensory limitations until an experience like this;" "it demonstrates the limitations a lot better than the Bárány chair;" "I was aware of the limitations of orientation senses, but not how easily they could be tricked by normal flight maneuvers;" "with the high proportion of accidents attributed to SD, this most effective demonstration of the limitations of the orientation senses should be incorporated into flight school—the money spent to conduct training would be recovered through a decreased accident rate;" "a great sortie, and the best and most practical demonstration I have seen to date;" and "a humbling experience!"

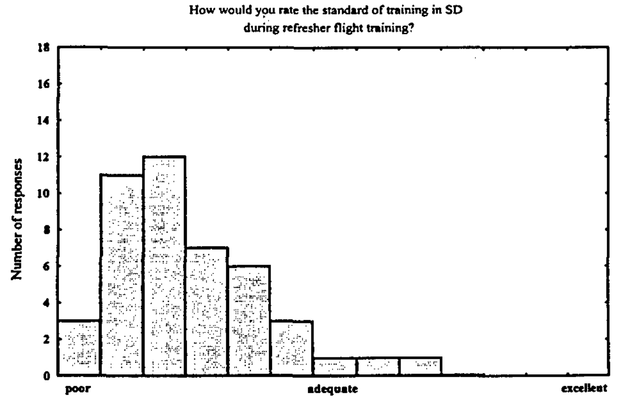


Fig. 4. Assessment of the standard of refresher SD training.

TABLE I. RATING OF THE TYPES OF SD TRAINING (BEFORE THE SD DEMONSTRATION SORTIE).

Type of Instruction	Number of Responses	Median Rating	25–75 Percentile Range
Classroom instruction	43	7.0	7.0–10.0
Discussion of SD accidents/incidents	33	7.0	6.0–10.0
Bárány chair	33	10.0	7.0–11.0
Other SD demonstration devices (e.g., ASDD*)	16	11.0	10.0–13.0
Recovery from unusual attitudes in an aircraft	31	9.0	7.0–10.0
Recovery from unusual attitudes in a flight simulator	33	10.0	7.0–11.0

Rating range: 0 = extremely poor, 7 = adequate, 13 = excellent.
* ASDD is the advanced spatial disorientation demonstrator at the U.S. Air Force School of Aviation Medicine, Brooks Air Force Base, TX.

Awareness of the Limitations of the Orientation Senses Following the SD Demonstration Sortie

Following the sortie, participants were asked to rate their awareness of the limitations of the orientation senses in flight compared with their previous knowledge. The distribution of responses to this question is shown in **Fig. 5**. The median rating was 10.5.

Assessment of the Types of SD Training (Post-Sortie)

This question was a repeat of the one that participants had answered before the sortie, but now included the SD sortie as a form of instruction. **Table III** summarizes the responses. Additional comments were as follows: "I thought that the SD demonstration sortie was much better than the ASDD;" "the sortie is an excellent demonstration, is much more realistic, and drives the point home a lot better than the Bárány chair." To compare ratings of individual types of instruction before and after the sortie, *t*-tests were performed. Only the rating of the rotating chair was significantly different. The mean rating before the sortie was 8.93, and 8.17 afterwards ($t = 2.21$, df = 28, $p = 0.035$).

Introduction of the SD Sortie into Army Flight Training

Participants were asked whether they thought that the sortie should be introduced into the various phases of U.S. Army aeromedical and flight training. All agreed that it should be introduced into the initial entry rotary-wing (IERW) flight training syllabus. Particular comments were as follows: "This training must be integrated into the program for all crewmembers;" "inclusion of this demonstration will awaken the new pilots from day one;" and "the SD sortie should be linked to instrument flight training, and the SD lecture should be scheduled close to the demonstration for reinforcement." The comments on the introduction of the sortie into transition and refresher training generally supported one of two views. First, those that felt that SD training should be stressed at every possible opportunity supported a further demonstration at these stages. Second, those who realized the fiscal constraints stated that while it would be highly desirable to repeat the sortie during transition training, it was probably not essential. This latter view was qualified by ensuring the maintenance of a high quality of instruction during the IERW course. A frequently made alternative suggestion was that the sortie could be readily incorporated into the annual proficiency and readiness test.

DISCUSSION

This assessment set out to determine whether the British Army SD demonstration sortie would be an effective adjunct to training aircrew in SD in the U.S. Army. The cross-section of aviators included a number of very experienced standardization instructor pilots (SIPs) whose comments were most valuable, as they are well positioned to influence the executive authorities on training issues. It was clear that most of the study participants regarded SD as a significant hazard associated with Army helicopter operations. Response data indicate that the quality of SD training in the U.S. Army during initial, transition, and refresher training should be improved to better reflect the operational significance of this hazard. In particular, it should receive greater attention during refresher training periods, and demonstration of the limitations of the orientation senses should be improved.

The maneuvers performed in the SD demonstration sortie, and the sortie overall, were extremely effective at demonstrating the limitations of the orientation senses. Further, the sortie was given a significantly higher rating in its effectiveness to train Army aviators in SD than all the currently available methods. All participants stated that the introduction of the sortie into the IERW flight training syllabus would be a distinct enhancement to the

TABLE II. RATING OF THE SD DEMONSTRATION SORTIE MANEUVERS AND THE SORTIE OVERALL.

	Subjects		Observers	
Maneuver	Median Rating	25–75 Percentile Range	Median Rating	25–75 Percentile Range
Level turn	12.0	11.5–13.0	12.0	11.5–12.5
Straight and level	12.5	11.0–13.0	11.5	10.5–12.5
Deceleration	12.0	11.0–12.5	12.0	11.5–12.5
Inadvertent descent	12.5	12.0–13.0	12.0	11.5–12.5
Hover maneuvers (as a whole)	12.5	12.0–13.0	12.5	11.5–13.0
The sortie overall (all participants)	12.5	11.5–13.0		

Rating range: 0 = extremely poor, 7 = adequate, 13 = excellent.

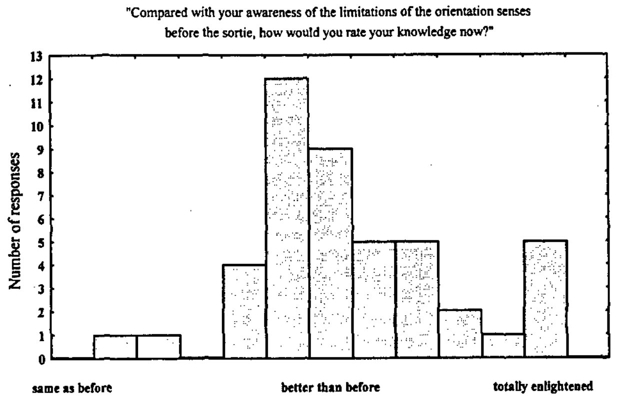


Fig. 5. Rating of "awareness" of the limitations of orientation. The rating scale was from 0 = "I know nothing about SD" through 7 = "same as before" to 13 = "totally enlightened." There were no ratings less than 7; therefore, only the range 7 through 13 is illustrated.

SD training of aviators and associated personnel. The introduction of the sortie into the refresher training in field units would also be an advantage. The following final comment from one of the SIPs attending the SD demonstration sortie is included below because it succinctly summarizes the advantages of this enhancement to SD training: "The demonstration was extremely beneficial because it so clearly demonstrated the physical limitations of our orientation system. As an instructor, I am enthused about the potential benefits to aviator training. I had stated on the preflight questionnaire that I did not think that many Army aviation accidents were related to SD, but I was wrong to say this. My scope was limited to actual instrument flight operations, but the application for this innovation is broad, covering all operations (particularly flight with NVDs and in the hover). We can attribute a lot of accidents to failure to maintain aircraft position. The Army needs to buy in to this proposed training without reservation."

It is stressed that this demonstration does not seek to train the aviator in how to deal with SD once it has occurred. That is the responsibility of the IP, and is being addressed under the auspices of the U.S. triservice technical working group on SD and situational awareness (4).

As the assessment was concluded to be successful, it was recommended that the SD demonstration sortie be introduced into the IERW flight training syllabus. A feasibility study is now being undertaken. Other services are encouraged to consider this enhancement to the SD training of aviators.

TABLE III. RATING OF THE TYPES OF SD TRAINING (AFTER THE SD DEMONSTRATION SORTIE).

Type of Instruction	Number of Responses	Median Rating	25–75 Percentile Range
Classroom instruction	43	7.0	6.0–10.0
Discussion of SD accidents/incidents	33	7.0	6.0–10.0
Bárány chair	33	8.0	6.0–10.0
Other SD demonstration devices (e.g., ASDD)	16	10.0	5.0–12.0
Recovery from unusual attitudes in an aircraft	31	10.0	7.0–11.0
Recovery from unusual attitudes in a flight simulator	33	10.0	9.0–12.0
The SD demonstration sortie*	45	13.0	12.0–13.0

Rating range: 0 = extremely poor, 7 = adequate, 13 = excellent.
* Significantly higher rating score than all the other forms of instruction (by Wilcoxon matched pairs signed ranks test).

REFERENCES

1. Braithwaite MG. Towards standardization in spatial disorientation. Position Paper to Working Party 61 of the Air Standardization Coordination Committee. 1994.
2. Braithwaite MG, Groh S, Alvarez EA. Spatial disorientation in U.S. Army helicopter accidents: an update of the 1987–92 survey to include 1993–95. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 97–13.
3. Braithwaite MG. The British Army Air Corps in-flight spatial disorientation demonstration sortie. Aviat Space Environ Med 1997; 68:342–5.
4. Braithwaite MG, DeRoche SL, Alvarez EA, Reese M. Proceedings of the first triservice conference on rotary-wing spatial disorientation: spatial disorientation in the operational rotary-wing environment. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 97–15.
5. Durnford S, Crowley JS, Rosado NR, et al. Spatial disorientation: a survey of U.S. Army helicopter accidents 1987–92. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 95–25.
6. Yauch DW, Ercoline WR, Previc FH, Holoviak SJ. The advanced spatial disorientation demonstrator: component, profile, and training evaluation. In: Selection and training advances in aviation. Proceedings of the Advisory Group for Aerospace Research and Development. Neuilly-sur-Seine: NATO-AGARD, 1996; 588:28–1 to 28–5.

REFRESHER PHYSIOLOGY IN AIRCRAFT SIMULATORS (SIMPHYS)

R.P. Mason
Aeromedical Safety Officer
Headquarters, United States Marine Corps
2 Navy Annex
Washington DC 20380-1775
United States

1. SUMMARY

The use of aircraft simulators in aviation training programs has increased significantly in recent years along with their capabilities and sophistication. Aircrew coordination training (ACT), aircraft systems checks, instrument rating checks, and emergency procedures training are currently being conducted in flight simulators. As flight simulator use and fidelity increases, the ability to replicate actual flight conditions and aeromedical safety issues are both enhanced. A simulator-based curriculum was developed by modifying the learning objectives from the existing rotary wing refresher aviation physiology and survival training curriculum to performance based objectives that could be demonstrated in a simulator-based curriculum. The AH-1W (Super Cobra) Weapons Systems Trainer (Device 2F136) at MCAS Camp Pendleton, CA was used as the simulator test bed. Fourteen pilots completed the prototype curriculum and were questioned on its efficacy. All fourteen pilots identified the simulator-based curriculum as superior to the existing curriculum and as more effective in meeting the curriculum's learning objectives. Substantial increases across all learning domains were demonstrated and a change in the pilots' attitudes towards refresher physiology training was noted. A simulator-based rotary wing refresher aviation physiology and survival training curriculum is feasible and should be adopted to provide effective aeromedical training for aircrew. Further evaluation is on going to determine the potential and effectiveness of a fast jet and transport simulator-based curricula.

2. INTRODUCTION

Primarily lectures, altitude chambers and ejection seat trainers deliver current refresher curricula for aeromedical and human factors issues. The use of these devices is valid because aircrews experience the physiology of high altitude and ejection. However, review of current mishap statistics indicates that the majority of aeromedical factors involved in mishaps are only discussed in the lecture format with no experiential learning. Examples of these aeromedical factors are unrecognized spatial disorientation, mid-air collisions, delayed ejection decisions, task saturation, controlled flight into terrain, and poor crew coordination. In some aeromedical training programs, spatial disorientation trainers have been procured and fielded in very limited quantities, as have human centrifuges for G-LOC training. These special devices are also considered part-task trainers because they focus on a specific aeromedical topic.

The traditional approach to acquiring training devices for hands-on aeromedical training has been to field part-task trainers. Use of part-task trainers can result in the proliferation of devices and creates a logistics problem that increases cost. As new training technology becomes available, the part-task trainers become obsolete or their age makes maintenance or modifications more expensive. Even with modifications, the scope of their intended training objective is still limited. It is less likely that a link will be made in real life application of the subject matter if the training syllabus does not provide crucial and timely links between the part-task trainer and the other objectives of the training program which support the trainer. Time to train can also increase when part-task trainers are introduced into a curriculum which is already time limited.

The use of aircraft simulators in aviation training programs has increased significantly in recent years along with their capabilities and sophistication. Simulator technology is advancing rapidly because of the commercial interest in virtual reality. Simulators provide mission oriented training in an operational setting and allow for exposure to potentially life threatening conditions without the associated risk. Aircraft simulators and associated training curricula currently exist at military installations worldwide. Each aircraft community has developed their own simulator requirements and there are significant differences between the communities on simulator use. Some communities have different types of simulators for the same aircraft and some communities do not even have simulator. In addition to weapons platform training, simulators are being used to conduct aircrew coordination training, annual aircraft flight procedures evaluations, annual instrument rating evaluations, and emergency procedures training.

Flight simulators are capable of replicating scenarios that can increase awareness of human factors and aeromedical issues, but there are no guidelines or curricula that take full advantage of these capabilities. Simulator flexibility allows for expansion to demonstrate even more aeromedical factors if a need is identified during data base programming. Simulator and new training technologies were reviewed for their potential to deliver physiological training to aircrew and for their potential to provide aircrew with experience in preventing the human factors causes of mishaps.

Paper presented at the RTO HFM Workshop on "Aeromedical Aspects of Aircrew Training", held in San Diego, USA, 14-18 October 1998, and published in RTO MP-21.

3. EVALUATION

A simulator-based curriculum was developed by modifying the learning objectives from the existing rotary wing refresher curriculum to performance based objectives which could be demonstrated in a simulator. The AH-1W Weapons Systems Trainer (Device 2F136) at MCAS Camp Pendleton, CA was used as the simulator test bed. The simulator-based curriculum consisted of: (1) a pre-flight brief that included a pre-test, a mission scenario brief, review of potential copilot 72-hour histories, and aviation life support equipment pre-flight inspection; (2) the simulator flight which consists of scenarios that offer demonstration of topics such as spatial disorientation, mid-air collisions, task saturation, controlled flight into terrain, and crew coordination; and (3) the post-flight which includes discussion of crash survivability, hands-on first-aid using moulaged mannequins, and aviation life support equipment darkroom drills to identify and properly use signaling devices. Fourteen pilots that represented the flight experience range of a typical Marine helicopter squadron participated in this study and answered a questionnaire upon completion of the prototype curriculum. Two educational specialists observed the training to assess the learning effectiveness of the simulator-based curriculum.

4. RESULTS

This study was designed to assess if current learning objectives could be successfully transitioned to simulator scenarios and measured for effectiveness. All learning objectives were met or exceeded during the assessment and all fourteen pilots unanimously preferred the simulator-based training to the existing conventional lecture format. All fourteen pilots identified the simulator-based curriculum as superior to the existing curriculum and as a more effective method of meeting the curriculum's learning objectives. Compared to the conventional training, levels of learning were assessed to be 250-350% higher in simulator-based training across all of the learning domains that resulted in much higher student retention. There is documented evidence that pilot attitudes toward aeromedical training were dramatically improved. The interaction between the instructor and student is particularly valuable as it allows the instructor to get feedback from the students and assess their knowledge. The aeromedical instructors (aviation physiologists and corpsmen) also benefit by getting thoroughly indoctrinated into the missions and capabilities of the aircraft communities that they serve. The simulator-based training scenarios were realistic enough to allow the pilots to complete other squadron training events.

5. CONCLUSIONS

This study demonstrated that existing flight simulators have significant features to serve as training devices for refresher aviation physiology and survival training. A simulator-based rotary wing refresher aviation physiology and survival training curriculum is feasible and should be adopted to provide effective aeromedical training for aircrew. Based upon the success of the rotary wing evaluation, a fast jet evaluation is underway with an F/A-18 weapons systems trainer simulator. This evaluation will incorporate the use of a reduced oxygen breathing device to induce hypoxia. This evaluation will use the same assessment tools used in the AH-1W evaluation.

Recommendations of the RTO/HFM Workshop on Aeromedical Aspects of Aircrew Training

RTO/HFM Workshop Attendees

INTRODUCTION

One of the objectives of the RTO/HFM Workshop was to review STANAG 3114 "Aeromedical Training of Flight Personnel". A second objective was to review current Aeromedical Training Programmes and make recommendations to improve training and increase safety.

Following two days of presentations on current Aeromedical Training Programmes and new approaches for providing this training, attendees spent a half-day reviewing STANAG 3114. From this discussion the Workshop developed recommendations for changes to the STANAG, which are included here. As well, the Workshop developed recommendations for research and the validation of the need for a new STANAG on Night Vision Device Training.

STANAG 3114

The Workshops recommendations for changes to STANAG 3114 are as follows:

1) change the structure to remove the rigid split between Fixed-Wing and Rotary-Wing aircraft and relate the training to the flying environment such as Fast-Jet, Multi-Engine or Rotary-Wing,

2) remove the specification of the number of hours of instruction and length of course,

3) change the requirement for Rotary-Wing aircrew to complete a 25,000 ft chamber exposure to 12,000 – 13,000 ft,

4) remove the requirement for a lecture on the aims and objectives of the training,

5) change M1 to AGSM,

6) should not specify lectures as the means of delivering training,

7) remove requirement to hold an aircrew medical category from para 7,

8) chamber training requirements should be reviewed for operational relevance,

9) add requirement for training on aeromedical aspects of new life support equipment,

10) add a requirement for a practical Spatial Disorientation experience on refresher training,

11) consider a review and update of para 11. a. (12), and

12) there is an over-definition of the instructor qualifications. Only requirement should be that they are appropriately qualified.

ADDITIONAL RECOMMENDATIONS

Beyond recommended changes to STANAG 3114 the Workshop made the following recommendations:

1) that NATO validate the requirement for a new STANAG on "Night Vision Device Training",

2) that the RTO/HFM establish a Working Group to investigate the variations between countries in Decompression Illness rates experienced due to altitude chamber exposure, and

3) that another HFM Workshop take place in three-to-five years to review the progress made in regards to the recommendations made by this Workshop and to discuss the best methodologies for providing Aeromedical Training.

CONCLUSIONS

This Workshop was highly successful. It brought together Aeromedical Trainers from many Countries and Branches of Service to review current Aeromedical Training Programmes and provided a forum for interaction and cooperation. The recommendations of the Workshop attendees, if actioned, will ensure Aeromedical Training Programmes continue to improve and develop and are ready to meet the needs of Aircrew into the next millennium.

REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's References	3. Further Reference	4. Security Classification of Document
	RTO-MP-21 AC/323(HFM)TP/8	ISBN 92-837-1016-9	UNCLASSIFIED/ UNLIMITED

5. Originator Research and Technology Organization
North Atlantic Treaty Organization
BP 25, 7 rue Ancelle, F-92201 Neuilly-sur-Seine Cedex, France

6. Title
Aeromedical Aspects of Aircrew Training

7. Presented at/sponsored by
the Human Factors and Medicine Panel (HFM) Workshop held in San Diego, USA, 14-18 October 1998.

8. Author(s)/Editor(s)	9. Date
Multiple	June 1999

10. Author's/Editor's Address	11. Pages
Multiple	96

12. Distribution Statement There are no restrictions on the distribution of this document. Information about the availability of this and other RTO unclassified publications is given on the back cover.

13. Keywords/Descriptors

Aerospace medicine	Human factors engineering
Flight crews	Life support systems
Pilot training	Altitude chambers
Survival training	Night vision
Aviation personnel	Decompression sickness
Spatial disorientation	NATO forces
Physiology	Training simulators
Air force training	Physiological effects
Flight simulators	

14. Abstract

A RTO Human Factors and Medicine Panel Workshop held in San Diego, California, in October 1998 brought together Aeromedical Trainers to discuss current Aeromedical Training Programmes and to present new approaches to this training. Various approaches to Aeromedical Training were also discussed and STANAG 3114 "Aeromedical Training of Flight Personnel" was reviewed. Presentations included: categories of training, subjects taught, frequency of training, duration of courses, period of validity and altitude chamber profiles utilized. Most NATO countries were present and provided overviews of their programmes, as did representatives from Poland and the Czech Republic. Presentations also included new approaches to Aeromedical Training including: Simulator Based Physiology Training (SYMPHYS), Simulator Based Disorientation Training and In-Flight Disorientation Training. The Workshop recommended changes to STANAG 3114 including, but not limited to: removal of the split between Rotary and Fixed-wing aircraft training requirements, addition of the requirement for instruction on aeromedical aspects of new Life Support Equipment and addition of the requirement for a practical Spatial Disorientation experience during refresher training. Also recommended was the establishment of a Working Group to study the variation between countries in rates of Decompression Illness from altitude chamber exposure. It was also recommended that NATO validate the need for a new STANAG on Night Vision Training.

NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION
BP 25 • 7 RUE ANCELLE
F-92201 NEUILLY-SUR-SEINE CEDEX • FRANCE
Télécopie 0(1)55.61.22.99 • E-mail mailbox@rta.nato.int

DIFFUSION DES PUBLICATIONS
RTO NON CLASSIFIEES

L'Organisation pour la recherche et la technologie de l'OTAN (RTO), détient un stock limité de certaines de ses publications récentes, ainsi que de celles de l'ancien AGARD (Groupe consultatif pour la recherche et les réalisations aérospatiales de l'OTAN). Celles-ci pourront éventuellement être obtenues sous forme de copie papier. Pour de plus amples renseignements concernant l'achat de ces ouvrages, adressez-vous par lettre ou par télécopie à l'adresse indiquée ci-dessus. Veuillez ne pas téléphoner.

Des exemplaires supplémentaires peuvent parfois être obtenus auprès des centres nationaux de distribution indiqués ci-dessous. Si vous souhaitez recevoir toutes les publications de la RTO, ou simplement celles qui concernent certains Panels, vous pouvez demander d'être inclus sur la liste d'envoi de l'un de ces centres.

Les publications de la RTO et de l'AGARD sont en vente auprès des agences de vente indiquées ci-dessous, sous forme de photocopie ou de microfiche. Certains originaux peuvent également être obtenus auprès de CASI.

CENTRES DE DIFFUSION NATIONAUX

ALLEMAGNE
Fachinformationszentrum Karlsruhe
D-76344 Eggenstein-Leopoldshafen 2

BELGIQUE
Coordinateur RTO - VSL/RTO
Etat-Major de la Force Aérienne
Quartier Reine Elisabeth
Rue d'Evère, B-1140 Bruxelles

CANADA
Directeur - Recherche et développement - Communications et gestion de l'information - DRDCGI 3
Ministère de la Défense nationale
Ottawa, Ontario K1A 0K2

DANEMARK
Danish Defence Research Establishment
Ryvangs Allé 1, P.O. Box 2715
DK-2100 Copenhagen Ø

ESPAGNE
INTA (RTO/AGARD Publications)
Carretera de Torrejón a Ajalvir, Pk.4
28850 Torrejón de Ardoz - Madrid

ETATS-UNIS
NASA Center for AeroSpace Information (CASI)
Parkway Center, 7121 Standard Drive
Hanover, MD 21076-1320

FRANCE
O.N.E.R.A. (Direction)
29, Avenue de la Division Leclerc
92322 Châtillon Cedex

GRECE
Hellenic Air Force
Air War College
Scientific and Technical Library
Dekelia Air Force Base
Dekelia, Athens TGA 1010

ISLANDE
Director of Aviation
c/o Flugrad
Reykjavik

ITALIE
Aeronautica Militare
Ufficio Stralcio RTO/AGARD
Aeroporto Pratica di Mare
00040 Pomezia (Roma)

LUXEMBOURG
Voir Belgique

NORVEGE
Norwegian Defence Research Establishment
Attn: Biblioteket
P.O. Box 25
N-2007 Kjeller

PAYS-BAS
NDRCC
DGM/DWOO
P.O. Box 20701
2500 ES Den Haag

PORTUGAL
Estado Maior da Força Aérea
SDFA - Centro de Documentação
Alfragide
P-2720 Amadora

ROYAUME-UNI
Defence Research Information Centre
Kentigern House
65 Brown Street
Glasgow G2 8EX

TURQUIE
Millî Savunma Başkanliği (MSB)
ARGE Dairesi Başkanliği (MSB)
06650 Bakanliklar - Ankara

AGENCES DE VENTE

NASA Center for AeroSpace Information (CASI)
Parkway Center
7121 Standard Drive
Hanover, MD 21076-1320
Etats-Unis

The British Library Document Supply Centre
Boston Spa, Wetherby
West Yorkshire LS23 7BQ
Royaume-Uni

Canada Institute for Scientific and Technical Information (CISTI)
National Research Council
Document Delivery,
Montreal Road, Building M-55
Ottawa K1A 0S2
Canada

Les demandes de documents RTO ou AGARD doivent comporter la dénomination "RTO" ou "AGARD" selon le cas, suivie du numéro de série (par exemple AGARD-AG-315). Des informations analogues, telles que le titre et la date de publication sont souhaitables. Des références bibliographiques complètes ainsi que des résumés des publications RTO et AGARD figurent dans les journaux suivants:

Scientific and Technical Aerospace Reports (STAR)
STAR peut être consulté en ligne au localisateur de ressources uniformes (URL) suivant:
http://www.sti.nasa.gov/Pubs/star/Star.html
STAR est édité par CASI dans le cadre du programme NASA d'information scientifique et technique (STI)
STI Program Office, MS 157A
NASA Langley Research Center
Hampton, Virginia 23681-0001
Etats-Unis

Government Reports Announcements & Index (GRA&I)
publié par le National Technical Information Service
Springfield
Virginia 2216
Etats-Unis
(accessible également en mode interactif dans la base de données bibliographiques en ligne du NTIS, et sur CD-ROM)

Imprimé par le Groupe Communication Canada Inc.
(membre de la Corporation St-Joseph)
45, boul. Sacré-Cœur, Hull (Québec), Canada K1A 0S7

NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION
BP 25 • 7 RUE ANCELLE
F-92201 NEUILLY-SUR-SEINE CEDEX • FRANCE
Telefax 0(1)55.61.22.99 • E-mail mailbox@rta.nato.int

DISTRIBUTION OFUNCLASSIFIED RTO PUBLICATIONS

NATO's Research and Technology Organization (RTO) holds limited quantities of some of its recent publications and those of the former AGARD (Advisory Group for Aerospace Research & Development of NATO), and these may be available for purchase in hard copy form. For more information, write or send a telefax to the address given above. **Please do not telephone.**

Further copies are sometimes available from the National Distribution Centres listed below. If you wish to receive all RTO publications, or just those relating to one or more specific RTO Panels, they may be willing to include you (or your organisation) in their distribution.

RTO and AGARD publications may be purchased from the Sales Agencies listed below, in photocopy or microfiche form. Original copies of some publications may be available from CASI.

NATIONAL DISTRIBUTION CENTRES

BELGIUM
Coordinateur RTO - VSL/RTO
Etat-Major de la Force Aérienne
Quartier Reine Elisabeth
Rue d'Evère, B-1140 Bruxelles

CANADA
Director Research & Development
Communications & Information
Management - DRDCIM 3
Dept of National Defence
Ottawa, Ontario K1A 0K2

DENMARK
Danish Defence Research Establishment
Ryvangs Allé 1, P.O. Box 2715
DK-2100 Copenhagen Ø

FRANCE
O.N.E.R.A. (Direction)
29 Avenue de la Division Leclerc
92322 Châtillon Cedex

GERMANY
Fachinformationszentrum Karlsruhe
D-76344 Eggenstein-Leopoldshafen 2

GREECE
Hellenic Air Force
Air War College
Scientific and Technical Library
Dekelia Air Force Base
Dekelia, Athens TGA 1010

ICELAND
Director of Aviation
c/o Flugrad
Reykjavik

ITALY
Aeronautica Militare
Ufficio Stralcio RTO/AGARD
Aeroporto Pratica di Mare
00040 Pomezia (Roma)

LUXEMBOURG
See Belgium

NETHERLANDS
NDRCC
DGM/DWOO
P.O. Box 20701
2500 ES Den Haag

NORWAY
Norwegian Defence Research Establishment
Attn: Biblioteket
P.O. Box 25
N-2007 Kjeller

PORTUGAL
Estado Maior da Força Aérea
SDFA - Centro de Documentação
Alfragide
P-2720 Amadora

SPAIN
INTA (RTO/AGARD Publications)
Carretera de Torrejón a Ajalvir, Pk.4
28850 Torrejón de Ardoz - Madrid

TURKEY
Millî Savunma Başkanliği (MSB)
ARGE Dairesi Başkanliği (MSB)
06650 Bakanliklar - Ankara

UNITED KINGDOM
Defence Research Information Centre
Kentigern House
65 Brown Street
Glasgow G2 8EX

UNITED STATES
NASA Center for AeroSpace Information (CASI)
Parkway Center, 7121 Standard Drive
Hanover, MD 21076-1320

SALES AGENCIES

NASA Center for AeroSpace Information (CASI)
Parkway Center
7121 Standard Drive
Hanover, MD 21076-1320
United States

The British Library Document Supply Centre
Boston Spa, Wetherby
West Yorkshire LS23 7BQ
United Kingdom

Canada Institute for Scientific and Technical Information (CISTI)
National Research Council
Document Delivery,
Montreal Road, Building M-55
Ottawa K1A 0S2
Canada

Requests for RTO or AGARD documents should include the word 'RTO' or 'AGARD', as appropriate, followed by the serial number (for example AGARD-AG-315). Collateral information such as title and publication date is desirable. Full bibliographical references and abstracts of RTO and AGARD publications are given in the following journals:

Scientific and Technical Aerospace Reports (STAR)
STAR is available on-line at the following uniform resource locator:
http://www.sti.nasa.gov/Pubs/star/Star.html
STAR is published by CASI for the NASA Scientific and Technical Information (STI) Program
STI Program Office, MS 157A
NASA Langley Research Center
Hampton, Virginia 23681-0001
United States

Government Reports Announcements & Index (GRA&I)
published by the National Technical Information Service
Springfield
Virginia 22161
United States
(also available online in the NTIS Bibliographic Database or on CD-ROM)

Printed by Canada Communication Group Inc.
(A St. Joseph Corporation Company)
45 Sacré-Cœur Blvd., Hull (Québec), Canada K1A 0S7

ISBN 92-837-1016-9